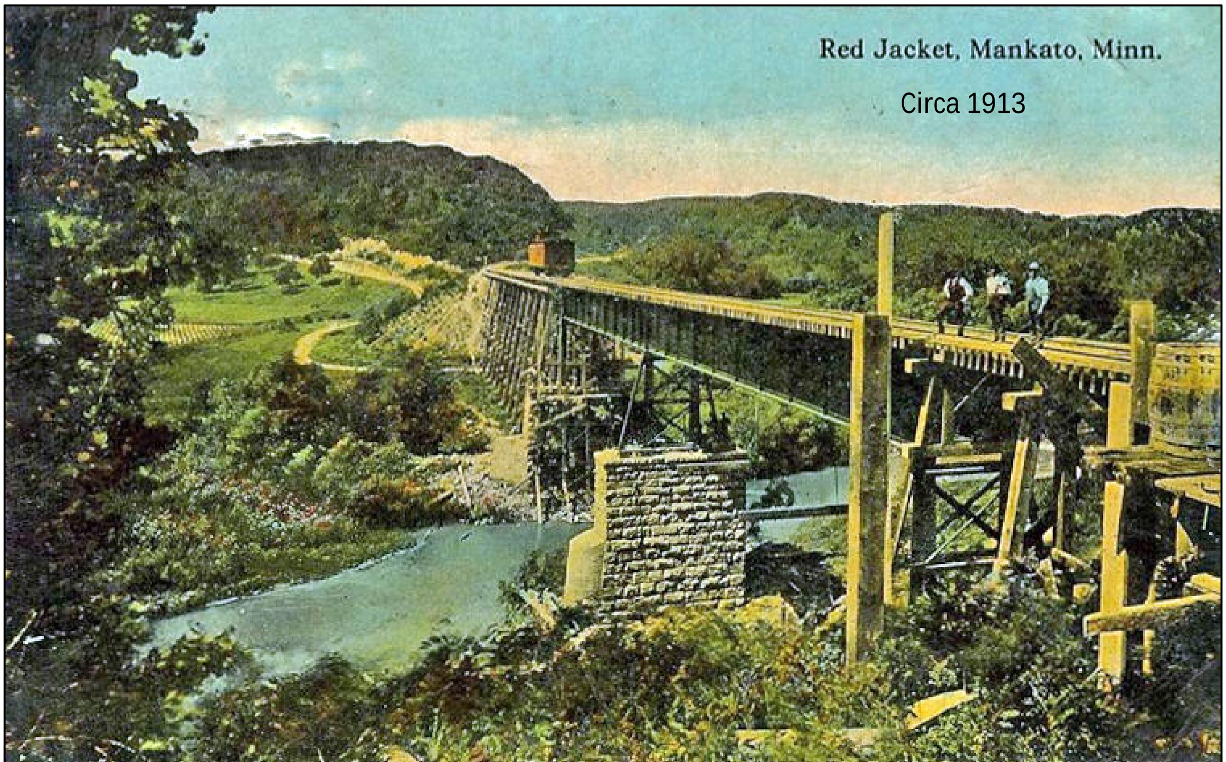
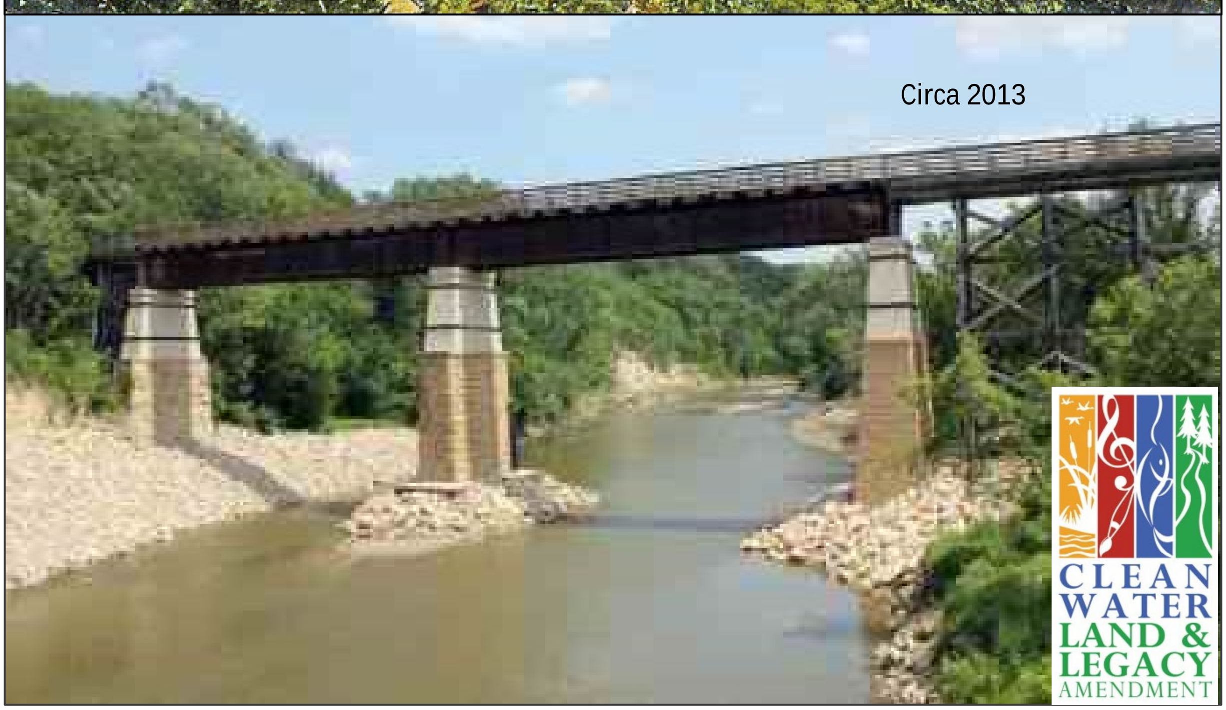
Le Sueur River WRAPS Report

Watershed conditions and restoration and protection strategies





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Cover pictures:

http://mankatotimes.com/2013/08/12/caring-for-the-red-jacket-bridge/

http://www.lakesnwoods.com/images/Mankat6.jpg

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Legislative Requirements

There are specific legislative definitions and requirements associated with Clean Water Legacy legislation on WRAPS (ROS 2013). Although the intent of this report is to be more comprehensive and usable than just merely meeting legislative requirements, this table is provided to help reviewers ensure those requirements are adequately addressed. However, the science, analysis and strategy development described in this report began before accountability provisions were added to the Clean Water Legacy Act in 2013; thus, this report may not address all of those provisions. When this watershed is revisited (according to the 10-year cycle), the information will be updated accordingly.

Legislative Requirement		
Section	Description	**Location in WRAPS report**
13.1.1	impaired and supporting waters	Figure 5 (pg 6); Table 1 (pg 7); Table 3 (pg 9)
13.1.2	biotic stressors	Table 3 (pg 9)
13.1.3	watershed modeling summary	Section 3.4 (pg 10), Appendix 6.2
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13.1.6	current pollutants and load reductions	Section 4.2 (pg 22); Appendix 6.5 (detailed)
13.1.7	monitoring plan	Section 3.1 (pg 4)
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13.1.8.i	water quality parameter of concern	Pollutant/Stressor Column (Table 8)
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13.1.8.v	timeline to achieve water quality targets	Under Estimated Years Column (Table 8)
13.1.8.vii	responsibility	Under Primary Role/Responsibility Column (Table 8)

An opportunity for public comment on the draft WRAPS report was provided via a public notice in the State Register from March 30th to April 29th, 2015.

1. Introduction

The State of Minnesota has adopted a "*Watershed Approach*" (MPCA 2013a) to address the water quality of each of the state's 80 major watersheds on a 10-year cycle. The goal of this Watershed Restoration and Protection Strategies (WRAPS) report is to summarize work done in this first application of the Watershed Approach in the Le Sueur River Watershed, which started in 2008. This work includes: water quality monitoring and assessment, pollutant and stressor identification, civic engagement/public participation, and restoration and protection strategy development. Ultimately, this work should be useful in local planning processes, which help guide conservation work within the watershed.

The work summarized in this report represents one of the first applications of the Watershed Approach in the State of Minnesota. This work by the Minnesota Pollution Control Agency (MPCA) and local partners used the best available data and emphasized citizen engagement in new ways. While this work generally produced good results, the Watershed Approach allows us to use the lessons learned and new science and data to revisit, update, improve, and expand work in subsequent applications.

The WRAPS report is intended to be a relatively short summary document that can be used by a variety of audiences to understand the watershed conditions and the restoration and protection strategy recommendations. This brevity is intended to provide a more readable and usable document; however, many details and nuances are lost. This report supplies hyperlinks to nearly all sources – the reader is encouraged to access these links to fully understand the summaries and recommendations made within this document.

What is the WRAPS Report?

Purpose

- Develop and present scientifically- and civically-supported restoration and protection strategies to be used for water and conservation planning and implementation
- Summarize Watershed Approach work done to date including:
  - Le Sueur River Watershed Monitoring and Assessment Report
  - Assessment Report of Selected Lakes within the Le Sueur River Watershed
  - Le Sueur River Watershed Biotic Stressor Identification Report
  - Le Sueur River Watershed Total Maximum Daily Load Report
  - Civic engagement, citizen recommendations, and local perspectives
  - Modeling and other important studies relevent to the watershed

Scope

- Impacts to aquatic recreation and impacts to aquatic life in assessed streams and lakes
- Watershed-wide water quality goals and 10-year targets

Audience

- Watershed citizens and stakeholders
- Local working groups: local governments, SWCDs, watershed groups, etc.
- State and Federal agencies: MPCA, DNR, BWSR, MDA, MDH, NRCS, etc.

2. Watershed Description & Background

The Le Sueur River major (HUC-8, [USGS, 2014]) watershed is located in south central Minnesota and drains approximately 711,000 acres (1,110 square miles) into the Le Sueur River. The Le Sueur River flows to the Blue Earth River and these waters join the Minnesota River near Mankato. The Le Sueur River Watershed is one of 12 major watersheds contributing to the Minnesota River basin. The Le Sueur Watershed consists of six Hydrologic Unit Code (HUC) - 10 subwatersheds: Rice Creek, Maple River, Cobb River, Little Cobb River, Upper Le Sueur River, and the Lower Le Sueur River (Figure 1a).

The Le Sueur River Watershed is largely rural with 82% of the land under agricultural cultivation (MRLC 2006). More than 90% of the watershed is in the Western Corn Belt Plains Ecoregion; however, a small area in the northern portion of the watershed is North Central Hardwood Forests Ecoregion (Figure 1b). The total population of the watershed is approximately 37,000 (estimated from 2010 U.S. census data) and contains several rural cities including: Eagle Lake, Mapleton, New Richland, Wells, and small portions of Waseca and Mankato. The watershed lies predominately in four counties: Blue Earth, Waseca, Faribault, and Freeborn, while small portions of the watershed fall in Steele and Le Sueur Counties.

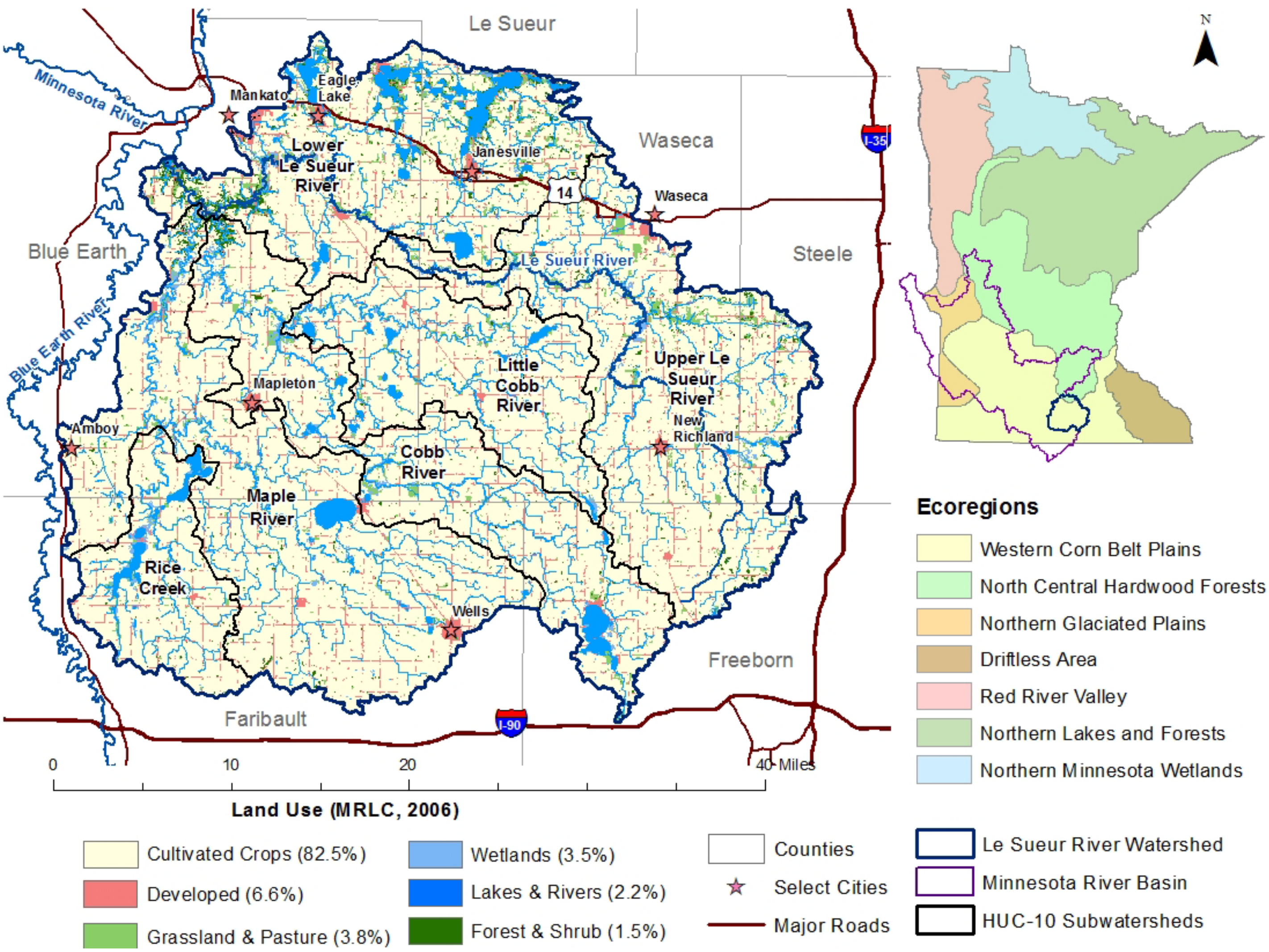


Figure 1a (left): The Le Sueur River watershed is dominated by row crops but also contains several rural cities. Six HUC-10 subwatersheds comprise this major watershed and portions of six counties fall in the watershed.
Figure 1b (upper right): The watershed is within the Minnesota River basin and mostly lies in the Western Corn Belt Ecoregion.

The Le Sueur River plays an important role as a drinking water source to the city of Mankato. The city of Mankato's drinking water well extracts water from bellow the Blue Earth River, of which roughly one-third is supplied by the Le Sueur River. The primary concern of this drinking water source is nitrogen concentrations, which are dangerous to human health and expensive to treat.

The watershed has three distinct topographical features that affect water quality (Figure 2). 1) The upper watershed, which is located in the southeast portion of the watershed. Waters in this area have few upstream contributions but impact downstream waters. 2) The former bed of Glacial Lake Minnesota, which is located in the central portion of the watershed. This area has a relatively flat topography and the soils of a glacial lake bottom: fine, erodible, and poorly drained. 3) The knick zone, which is located in the northwest portion of the watershed. This area contains migrating knickpoints, which are locations where the stream slope changes in an attempt to match the much lower elevation of the Minnesota River. This creates steep, eroding banks, bluffs, and ravines in the downstream portions of the river and a system susceptible to high erosion rates. In a *Geomorphic Evolution of the Le Sueur River and Implications for Current Sediment Loading*, Gran et al. (2009) present a detailed discussion of this topic.

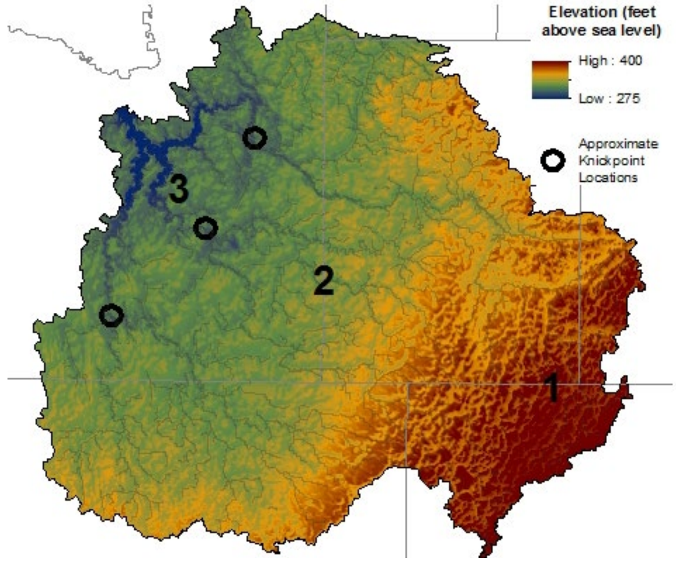


Figure 2: The topographic features, as shown in this digital elevation model map of the Le Sueur River watershed, partly explain why the watershed is susceptible to stream bank and bluff erosion.

The ditching and drainage of hydric soils and wetland basins that facilitated European settlement and farming has caused significant changes to the ecosystems and hydrology of the watershed. Substantial wetland complexes have been replaced by ditches via channelization (EPA 2007) (Figure 3). According to an *Intensified Tile Drainage Evaluation* (Schottler 2012), approximately 47% of the total watershed has been tile drained since settlement. This altered hydrology affects sediment delivery, nutrient cycling, and habitat as described in *Effects of Agricultural Drainage on Aquatic Systems* (Blann et al. 2009).

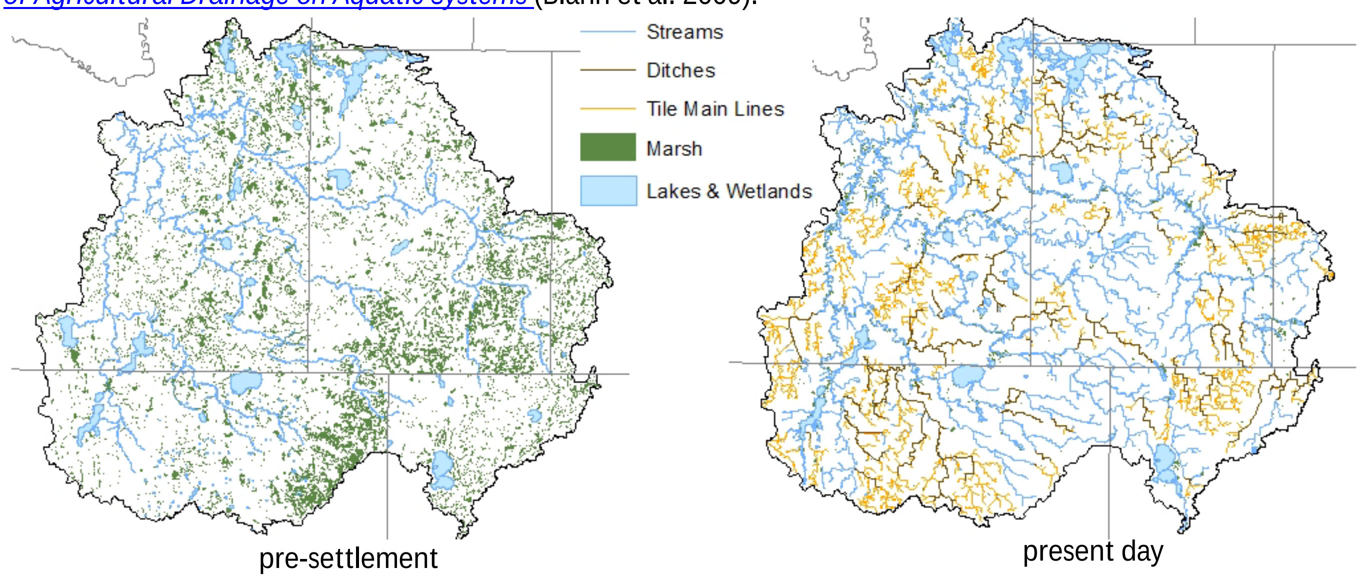


Figure 3: Since European settlement, substantial alterations were made to the natural waterways and wetlands of the Le Sueur River watershed. These changes have altered the hydrology of the watershed: much of what evapotranspirated from wetlands and prairies is now routed through field tiles (not shown), in to tile main lines then ditches, and finally to streams and rivers.

3. Watershed Conditions

{Are the waters clean or polluted?}

This section summarizes monitoring, assessment, stressor identification, computer modeling, and trend analysis work that were completed by the MPCA and local partners. More information on watershed conditions can be found at: *Science Briefing Book* (MSU 2013), the *Rapid Watershed Assessment* (NRCS 2010), and the *Watershed Health Assessment Framework* (DNR 2013).

3.1 Programs to Monitor Conditions

Data from three water quality monitoring programs enables water quality condition assessment and creates a long-term data set to track progress towards water quality goals. These programs will continue to collect and analyze data in the Le Sueur River watershed as part of *Minnesota's Water Quality Monitoring Strategy* (MPCA 2011b). Data needs are considered by each program and additional monitoring is implemented when deemed necessary and feasible. These monitoring programs are summarized below:

Watershed Pollutant Load Monitoring Network (MPCA 2013j) data provide a continuous and long-term record of water quality conditions at the major watershed and subwatershed scale. This program collects pollutant samples and flow data to calculate continuous daily flow, sediment, and nutrient loads. In the Le Sueur River Watershed, there is an annual site near the outlet of the Le Sueur River and five seasonal (spring through fall) subwatershed sites.

Intensive Watershed Monitoring (MPCA 2012b) data provide a periodic but intensive "snapshot" of water quality throughout the watershed. This program collects water quality and biological data at roughly 100 stream and 50 lake monitoring stations across the watershed in one to two years, every 10 years. This work is scheduled to start its second iteration in the Le Sueur River Watershed in 2018.

Citizen Stream and Lake Monitoring Program (MPCA 2013d) data provide a continuous record of water body transparency throughout much of the watershed. This program relies on a network of volunteers who make monthly lake and river measurements. Roughly 100 citizen monitoring locations exist in the Le Sueur River Watershed.

3.2 Conditions across the State

Data from the Watershed Pollutant Load Monitoring Network (MPCA 2012j) indicates that the Le Sueur River Watershed is one of the highest polluting watersheds in the State of Minnesota. As illustrated in Figure 4, the Le Sueur River Watershed contributes high yields and flow-weighted mean concentrations (FWMC) of water pollutants including total suspended sediment (TSS), total phosphorus (TP), and total nitrogen (TN). The yield, reported in pounds per acre, indicates the total amount of pollutant leaving the major watershed normalized by the contributing area of the watershed. While high pollutant yields affect waters within the watershed, the yield is particularly useful to determine impacts to downstream waters. The FWMC, reported in milligrams per liter, indicates the total amount of pollutant normalized by the amount of water. Similarly, while high concentration of pollutants impact downstream waters, the FWMC is particularly useful to determine impacts of pollutants within the watershed.

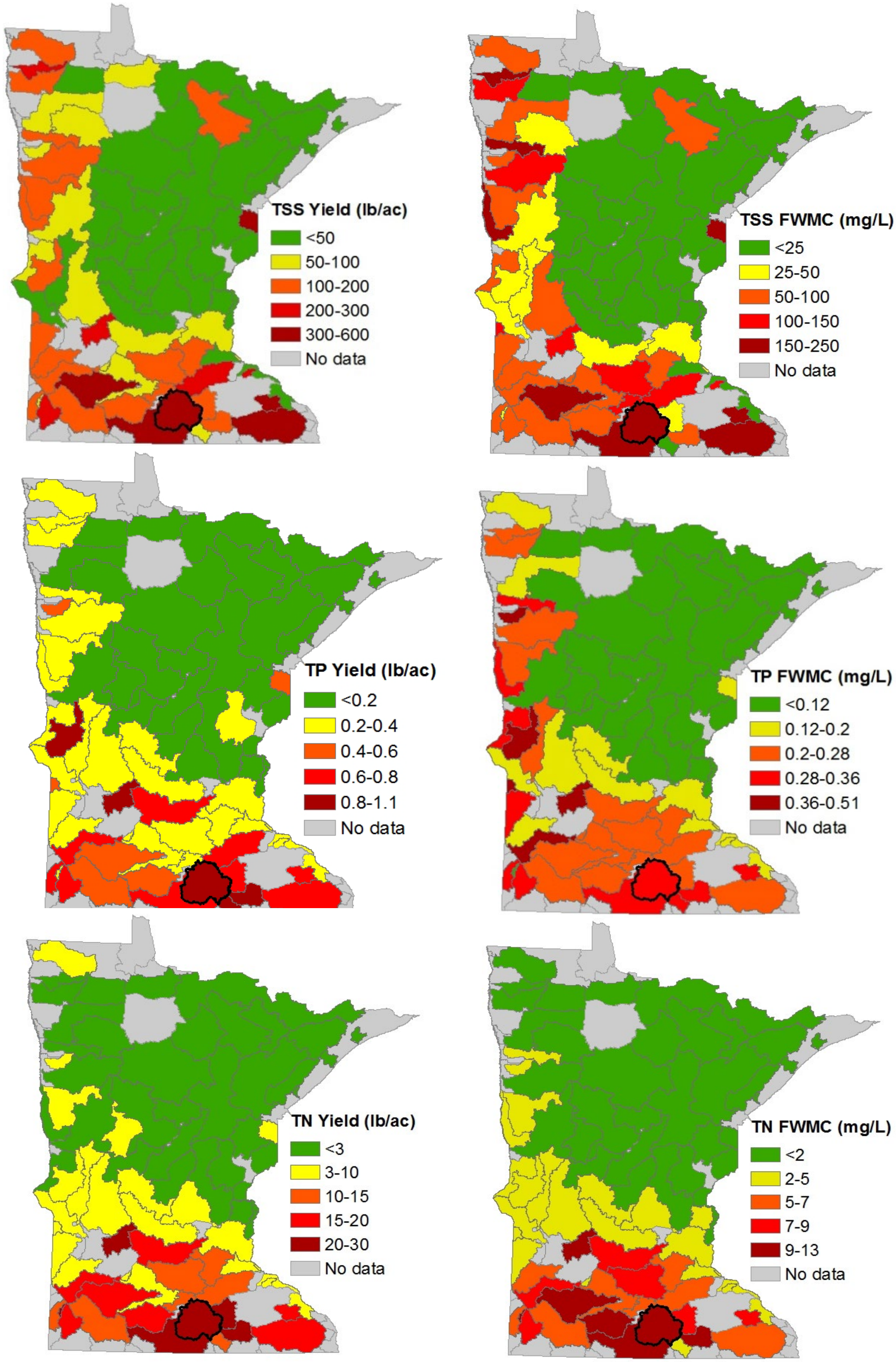


Figure 4: The Le Sueur River watershed (outlined in black) is one of the highest contributors of pollutants in Minnesota, as indicated by the pollutant yields (left). The river's outlet also has very high flow-weighted mean concentrations (FWMC) of pollutants (right), indicating that high pollutant concentrations, and thus "impairments", are likely common in the watershed. These data are from 2007-2011 from the Pollutant Load Monitoring Network (PCA, 2012j).

3.3 Conditions in the Watershed

Via the Intensive Watershed Monitoring Program (MPCA 2012b) and several previous TMDL studies (links provided in Section 4), streams and lakes in the Le Sueur River Watershed were monitored for pollutants and biological indicators of water body health. The monitoring results were compared against the established

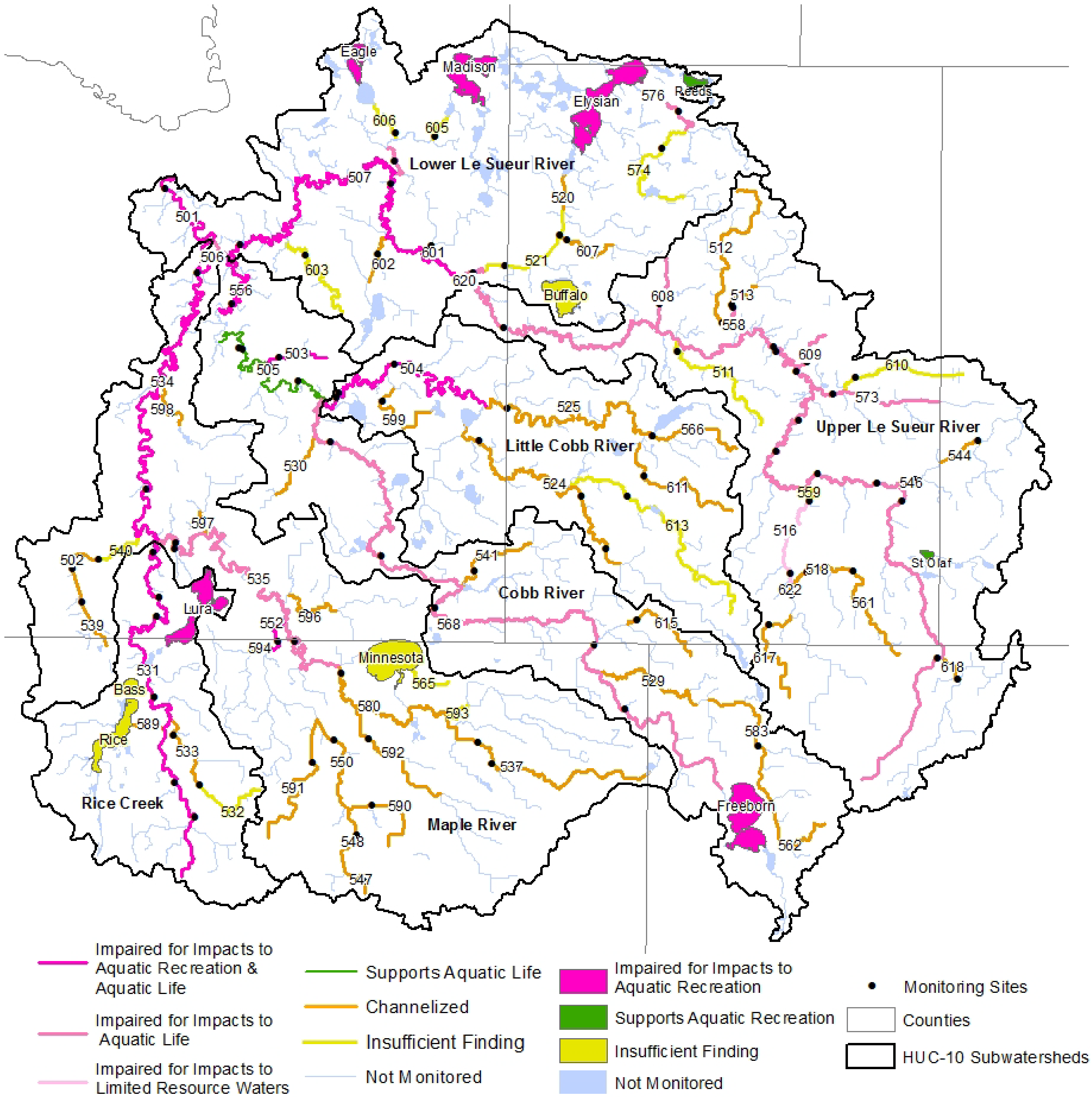


Figure 5: Stream and lake impairments were identified throughout the Le Sueur River watershed (in shades of pink). Very few waters were found to support their designated use (in green). Furthermore, more than half of the monitored stream reaches were channelized and cannot be assessed yet because standards are under development for channelized streams (in orange). Some water bodies did not have a robust enough data set to make a scientifically-conclusive finding (in yellow). The monitored lakes are noted by lake name and the monitored stream reaches are noted by the last three digits of the assessment unit identifier (AUID). Refer to Tables 1 and 3 for more details.

water quality standards (MPCA 2014a) associated with the beneficial use(s) of the specific water bodies. Beneficial uses include: 1) aquatic recreation (the safety of the water for swimming), 2) aquatic life (the ability of the water to support fish and bugs), and 3) aquatic consumption (the safety of eating the fish), and other uses. Water bodies were assessed as supporting or impaired (MPCA 2011a) for their beneficial use depending on whether they did or did not (respectively) meet the water quality standards.

In addition to the current condition of a water body, trends in water quality indicate if a water body is improving or declining. Beyond identifying a trend, however, numeric methods are necessary to determine whether the observed trend is statistically significant. Trends that are not statistically significant are not reliable. Because river outlets aggregate all waters from their watershed, water quality trends at river outlets can be particularly important in understanding watershed health as a whole.

In 2008-2009, 74 of the 136 stream Assessment Unit Identification (AUID) reaches and 9 of the 52 lakes in the Le Sueur River Watershed were monitored and assessed as impaired or supporting at least one of their beneficial uses (Figure 5). Several of the stream reaches and lakes were not able to be assessed due to being channelized or having insufficient data. None of the 54 protected wetlands were monitored in this iteration of the Watershed Approach. A summary of results is included here; refer to the *Le Sueur River Watershed Monitoring and Assessment Report* (M&A Report; MPCA 2012d) for full details. Additionally, lake and stream data (MPCA, 2013c) can be accessed online.

This report covers only impairments to aquatic recreation and aquatic life. Several lakes and stream reaches are impaired for aquatic consumption (due to mercury and PCBs). The *State-wide Mercury TMDL* (MPCA 2007) has been published and *Fish Consumption Advice* (MDH 2013) is available from the Department of Health.

Lake Conditions and Trends

The *Assessment Report of Selected Lakes within the Le Sueur River Watershed* (Lakes Report, MPCA 2010) integrates impairment information from the M&A Report (MPCA 2012d) and lake modeling completed for the watershed. Of the eleven lakes that were monitored, two supported aquatic recreation, five were impaired for impacts to aquatic recreation, and five were not assessed due to insufficient data to make a scientifically conclusive finding (Table 1). The parameters considered for assessment, specified by lake depth and eco-region, are: clarity, chlorophyll-a, and phosphorus. Lakes are not assessed for impacts to aquatic life at this time.

Table 1: Only two of the 11 monitored lakes in the Le Sueur River watershed are currently meeting water quality standards for aquatic recreation. Five of the lakes were found to be impaired. A handful of trends have emerged in the water clarity data including a declining trend in St. Olaf Lake, which may not meet standards in the future if action is not taken to reverse this declining trend.

HUC-10 Sub-watershed	Lake	Assesment for Aquatic Recreation	Water Clarity Trend
Rice	Lura	Impaired	No Evidence of Trend
	Bass	Insufficient Data	No Evidence of Trend
	Rice	Insufficient Data	No Data
Maple	Minnesota	Insufficient Data	No Evidence of Trend
Cobb	Freeborn	Impaired	No Data
Upper Le Sueur	St Olaf	Supporting	Decreasing Trend
Lower Le Sueur	Reeds	Supporting	Increasing Trend
	Madison	Impaired	No Evidence of Trend
	Eagle (North)	Impaired	Insufficient Data
	Elysian (Uppe	Impaired	Decreasing Trend
	Buffalo	Insufficient Data	Insufficient Data

Data from the Citizen Surface Water Monitoring Program were analyzed for trends. Of the roughly 70 lakes and stream reaches that were analyzed, only 3 lakes had detectable trends (or enough information to detect a trend). Those lake trends are also summarized in Table 1. Locations with at least 8 years of data and 25 season-year pairings were analyzed using the Seasonal Kendall method with 90% confidence.

In addition to the water quality standard assessment, the Sentinel Lakes (MPCA 2013o) program was started to understand and predict the consequences of land use and climate change on lake habitats. The program includes monitoring and assessment of multiple lake quality parameters including water chemistry, biology, blue-green algae, and others. The two lakes in the Le Sueur river watershed associated with this program (and the associated reports are): *Sentinel Lake Assessment Report – Madison Lake* (MPCA 2010b) and *Sentinel Lakes Assessment Report – St. Olaf Lake* (MPCA 2012c).

Stream Conditions and Trends

Of the 74 stream reaches that were monitored, 22 were assessed: one supported aquatic life, 12 were impaired for impacts to aquatic life, 8 were impaired for impacts to aquatic life and impaired for impacts to aquatic recreation, and one was impaired for impacts to a limited resource water. Fifty-two of the 74 monitored stream reaches could not be assessed: 12 due to insufficient data to make a scientifically conclusive finding and 40 due to being greater than 50% channelized. These streams will be assessed once Index of Biological Integrity (IBI) score standards for these channelized streams are finalized under the tiered aquatic life use framework (MPCA 2012a). The assessment statuses of the Le Sueur River Watershed's assessed stream reaches are presented in Table 3. Assessments are organized by designated use and indicate: 1) the overall assessment for the designated use, 2) the assessment for each parameter considered as part of the designated use assessment, and 3) the identified stressors of biologically-impaired stream reaches.

Stream reaches are impaired for impacts to aquatic life when one or more relevant parameters [(TSS), dissolved oxygen (DO), Fish IBI, or Macroinvertebrate IBI] do not meet the water quality standard. Many of the aquatic life impairments in the Le Sueur River Watershed were due to low IBI scores, which means that the fish or macroinvertebrate populations were low or dominated by pollution-tolerant species (refer to the M&A (MPCA 2012d) report for details). Streams that are impaired for impacts to aquatic life because of low IBI scores are referred to as biologically-impaired streams. The causes of these biological impairments, or "stressors", were identified in a formal stressor identification process as detailed in the Le Sueur River Watershed Biotic Stressor Identification report (MPCA 2014c). In summary, the primary stressors were identified through an intensive analysis of data, including application of the Causal Analysis/Diagnosis Decision Information System (EPA 2012). Refer to Table 3 for the identified stressors which include: altered hydrology; poor habitat; and high turbidity, nitrate, and phosphorus concentrations; low DO concentrations; and lack of connectivity.

Water quality data from 1998-2008 from the outlets of the Le Sueur River and the Little Cobb River were analyzed in the *Minnesota River Basin Statistical Trend Analysis* (MSU 2009). Both the Seasonal Kendall and QWTREND analysis methods were used to calculate trends at the 95% confidence level using two data sets: 1) instantaneous "grab" samples and 2) grab samples and continuous "composite" samples. The report warns of the weaknesses of a relatively limited data set (only 10 years) and many trends are not statistically significant, but some parameters do show improvement.

Table 2: Several trends in 1998-2008 data were not statistically significant (in grey) but based on this initial analysis, several water quality parameters improved (negative values, in green). After future data is collected, more statistically significant trends should become apparent. Instantaneous grab samples and grab samples plus continuous composite samples data sets were both analyzed.

	Le Sueur River			Little Cobb	
	QWTREND		Seasonal Kendall		
Parameter	(grab)	(w/ comp)	(grab)	(grab)	(w/ comp)
TSS	6%	**7%**	-25%	**-42%**	**-45%**
NO_3	-25%	**-37%**	-2%	**-23%**	**-23%**
TP	-14%	-15%	**-27%**	-2%	-11%
PO_4	**-36%**	**-35%**	2%	26%	8%
Flow			6%		

[Minnesota River Basin Trends](#) (Musser et al. 2009) discusses many additional changes that affect water quality trends.

Table 3: 21 stream reaches are impaired for their designated use (aquatic life, aquatic recreation, or limited resource). Only one stream reach supports its designated use. An additional 10 stream reaches had an assessment of at least one parameter, but a full assessment of the designated use will not be made until additional evidence is evaluated.

				Designated Use																
				Aquatic Life												Aquatic Rec		Limited Resource		
					Parameters				Stessors								Par		Par	
HUC-10 Sub-watershed	AUID (Last 3 digits)	Stream, Reach Description	Stream Class*	Assessment for Designated Use	Dis. Oxygen	Sediment/Tur.	Fish IBI	Invert. IBI	Dis. Oxygen	Phosphorus	Nitrate	Sediment/Tur.	Habitat	Hydrology	Connectivity	Assessment for Designated Use	Bacteria	Assessment for Designated Use	Bacteria	Dis. Oxygen
Rice	531	Rice Cr, Headwaters-Maple R	2B	Imp	IF	Imp	Imp	Imp	Y	Y	Y	Y	Y	Y	N	Imp	Imp	-		
Maple River	534	Maple R, Rice Cr-Le Sueur R	2B	Imp	IF	Imp	Sup	Imp	N	Y	Y	Y	Y	Y	N	Imp	Imp	-		
	535	Maple R, Minnesota Lk-Rice Cr	2B	Imp		Imp	Imp	Imp	N	IF	IF	Y	Y	Y	N			-		
	552	CD 3/JD 9, JD 9-Maple R	2B	Imp	IF	Imp	NA	NA								Imp	Imp	-		
	565	Unnamed Cr, Headwaters-Minnesota	2B	IF		Sup												-		
	593	CD 85, Unnamed Cr-Maple R	2B	IF			Imp	Imp										-		
Cobb River	503	Unnamed/Little Beauford, HW-Cobb R	2B	Imp	IF	Imp	NA	NA								Imp	Imp	-		
	505	Cobb R, Little Cobb R-T107 R27W S36	2C	Sup			Sup	Sup										-		
	556	Cobb R, T107 R26W S30-Le Sueur R	2C	Imp	IF	Imp	Imp	Sup	N	Y	Y	Y	Y	Y	N	Imp	Imp	-		
	568	Cobb R, T104 R23W S34-Little Cobb R	2C	Imp		Imp	Imp	Imp	N	IF	IF	Y	Y	Y	N			-		
Little Cobb	504	Little Cobb R, Bull Run Cr-Cobb R	2C	Imp	Imp	Imp	Imp		Y	Y	Y	Y	Y	Y	N	Imp	Imp	-		
	613	Unnamed Cr, Headwaters-Unnamed C	2B	IF			Imp											-		
Upper Le Sueur River	511	CD 35, Headwaters-Le Sueur R	2B	IF			Imp	Imp										-		
	516	Boot Cr, Unnamed Cr-T105 R22W S6	7	NA			NA									-		Imp	Imp	IF
	558	CD 12, T107 R23W S27-Unnamed Cr	2B	Imp			Imp	Imp	IF	IF	IF	N	Y	Y	N			-		
	573	Little Le Sueur R, T106 R22W S12-Le Su	2C	Imp			Imp	Sup	IF	IF	IF	N	Y	Y	N			-		
	608	CD 19, Headwaters-Le Sueur R	2B	Imp			Imp	Imp	IF	IF	IF	N	Y	Y	N			-		
	609	CD 15-2, Headwaters-Le Sueur R	2B	Imp			Imp	Imp	IF	IF	IF	IF	Y	Y	N			-		
	610	JD 10, Headwaters-Little Le Sueur R	2B	IF			Imp	Imp										-		
	619	Le Sueur R, Headwaters-Boot Cr	2B	Imp		Imp	Imp	Sup	N	IF	IF	Y	N	Y	N			-		
	620	Le Sueur R, Boot Cr-CD 6	2B	Imp		Imp	Sup	Sup										-		
Lower Le Sueur River	501	Le Sueur R, Maple R-Blue Earth R	2B	Imp	IF	Imp	Imp	Sup	N	Y	Y	Y	Y	Y	N	Imp	Imp	-		
	506	Le Sueur R, Cobb R-Maple R	2B	Imp		Imp	Sup	Sup										-		
	507	Le Sueur R, CD 6-Cobb R	2B	Imp	IF	Imp	Imp	Sup	N	Y	Y	Y	Y	Y	N	Imp	Imp	-		
	510	Unnamed Cr, Unnamed Cr-Le Sueur R	2B	Imp			Sup	Imp	IF	IF	IF	IF	Y	Y	N			-		
	521	CD 6, T107 R24W S4-T107 R25W S13	7	NA			NA	NA								-		IF	Sup	IF
	522	CD 6, T107 R25W S14-Le Sueur R	2B	Imp			Sup	Imp	N	IF	N	IF	Y	Y	Y			-		
	574	Silver Cr/ 3, Unnamed ditch-Iosco Cr	2C	IF			Imp	Imp										-		
	576	Iosco Cr, Silver Cr-T108 R23W S7	2C	Imp			Imp	Imp	IF	IF	IF	N	Y	Y	N			-		
	603	Unnamed Cr, Headwaters-Unnamed C	2B	IF			Imp											-		
	605	Unnamed Cr, Mud Lk -Unnamed Cr	2B	IF			Imp											-		
	606	Unnamed Cr, Eagle Lk-Unnamed Cr	2B	IF			Imp	Imp										-		

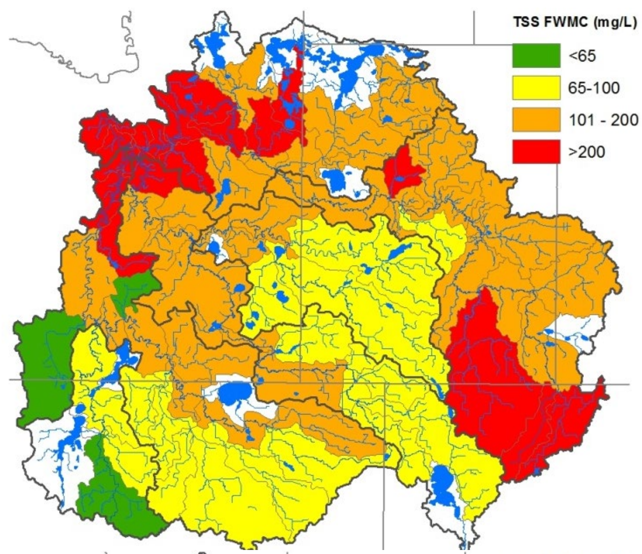
Sup	=	supports/meets	N	=	no, not a stressor to fish and/or macroinvertebrates
Imp	=	impaired/does not meet	Y	=	yes, a stressor to fish and/or macroinvertebrates
-	=	not applicable	IF	=	insufficient data to make a scientifically conclusive finding
<blank>	=	not evaluated	NA	=	not assessable until standards are developed for channelized Class 2 or Class 7 streams
*	=	see Appendix for Stream Class information			

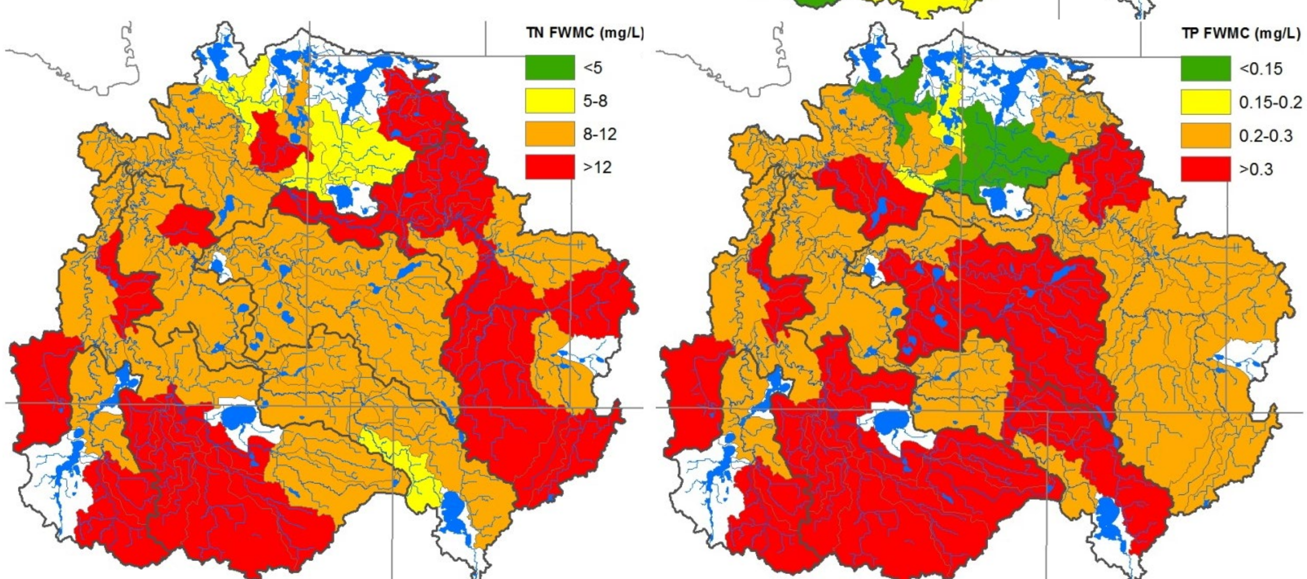
3.4 HSPF Modeled Conditions

While stream monitoring for pollutants within the Le Sueur River Watershed has generally been extensive, not every stream reach can be monitored due to financial and logistical constraints. Computer modeling can extrapolate the known conditions of the watershed to areas with less monitoring data. Computer models, such as [Hydrological Simulation Program – FORTRAN](#) (HSPF [USGS 2013a]), represent complex natural phenomena with numeric estimates and equations of natural features and processes. HSPF incorporates stream pollutant monitoring data, land use, weather, soil type, etc. to estimate water quality conditions across the watershed. *[Building a Picture of a Watershed](#)* (MPCA 2014d) explains the model's uses and development.

The Le Sueur River Watershed was modeled with HSPF, breaking the watershed into approximately 90 subwatersheds to illustrate the variability across the watershed. The 1996-2009 pollutant flow-weighted mean concentrations (FWMC) of TP, TN, and TSS at the stream reach outlets were modeled (Figure 6). These model data provide a reasonable estimate of pollutant concentrations across the watershed. These maps can be used to target conservation practices to reduce local or downstream pollutant concentrations. However, these data are not used for impairment assessments since monitoring data is required for those assessments. The FWMC from lake-dominated subwatersheds are not presented due to the lake-modeling limitations in this calibration of the model.

HSPF modeled pollutant yields (mass per acre) per subwatershed are presented in Section 4. Those maps can be used to target conservation practices to high contributing areas to minimize the total pollutant mass.





Figu[illegible] subwatershed outlet. Subwatershed areas in red are estimated to have the highest pollutant concentrations, while those in green are estimated to be (close to) meeting the watershed's water quality goal (see Section 0 for water quality goals).

4. Pollutant/Stressor Sources & Reductions

{Where is pollution coming from and how much pollution can waters handle?}

This section summarizes scientific analyses and *Total Maximum Daily Load* (TMDL) studies (MPCA 2013b) that identify sources of pollutants/stressors and the estimated pollutant/stressor reduction necessary for water bodies to meet their designated use. Readers should refer directly to the TMDL project webpages for details: *Le Sueur River Watershed TMDL* (MPCA 2015), *Blue Earth River Basin – Fecal Coliform* (MPCA 2013k), *Blue Earth River Basin - Turbidity* (MPCA 2013l), *Lower Minnesota River – Low Dissolved Oxygen (MPCA* 2013m), *Lura Lake – Excess Nutrients* (MPCA 2013n), *Minnesota River - Turbidity* (MPCA 2013p).

4.1 Source Identification

In the Le Sueur River Watershed, non-point pollutant sources dominate pollutant contributions. Permitted point source National Pollutant Discharge Elimination System (NPDES) (EPA 2013) facilities (see in Appendix 6.12) and Municipal Separate Storm Sewer Systems (MS4), city stormwater (from Mankato and Waseca with a current and expansion total area of 2% of the watershed), have relatively small pollution contributions at the watershed scale. The section summarizes multiple analyses to ensure an accurate identification of pollutant sources including:

- HSPF modeling done by RESPEC Consulting and the MPCA staff using 1996-2009 data inputs
- Soil and Water Assessment Tool (*SWAT*) (TAMU 2013) *Modeling of Sediment, Nutrients… in the Le Sueur River Watershed* (Folle 2010)
- Studies completed by the MPCA or other scientific or academic sources as noted
- Edge-of-field data (Discovery Farms 2013) from farm BE1 in the Le Sueur River Watershed (This data is supplemental and should not be interpreted as a representative sample; see notes in Appendix 6.1.)

Altered Hydrology

The interconnected forms of altered hydrology (USGS 2013) are widespread in the Le Sueur River Watershed. Increased river flows and flashiness (or rapid increases after rain) are obvious forms of altered hydrology. However, river flow increases are simply the manifestation of other hydrologic alterations including: increases in precipitation and decreases in evapotranspiration (ET) and residence time on the landscape. Decreases in ET and residence time are due to hydrologic alterations including: wetland loss, vegetation change, ditching and tiling, and impervious surfaces with storm drains. Figure 7 illustrates how converting land use from wetland and grasses to corn and soybeans affects ET rates.

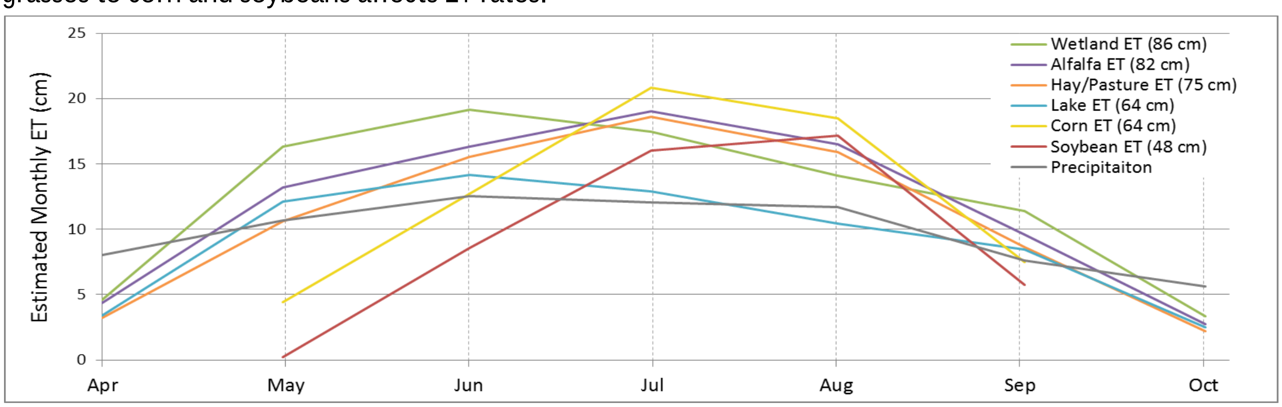


Figure 7: Since European settlement, perennial prairies and wetlands were replaced first by diverse crops and then by corn and soybeans. The total annual ET rates (indicated in the figure legend) of these replacement crops are smaller and the timing of ET through the year has shifted. These changes affect the hydrology of the watershed. See Appendix 6.10 for data sources and calculations.

Many of the major hydrologic alterations in the Le Sueur River Watershed occurred in the late-19th to early-20th century, but substantial changes have also occurred since then. Some of the most recent hydrologic alterations include increases in tiled acres, tile density, precipitation, the replacement of Conservation Reserve Program (FSA 2013) land with cropped land, and increased impervious surfaces.

Figure 9 shows six geographic information systems (GIS) analyses of Le Sueur River Watershed hydrologic parameters. The analyses indicate the estimated amount of change since European settlement and include: 1) the percent of land area which is estimated to be tiled, 2) the percent of wetland area that is estimated to have been lost, 3) the percent of stream length that has been channelized/artificially straightened, 4) the percent increase in stream/waterway lengths (due to adding ditches), 5) the percent of land not in perennial vegetation, and 6) the percent of land that is covered with an impervious surface. This information can be used to understand the cause and extent of altered hydrology and target conservation work aimed at mitigating altered hydrology.

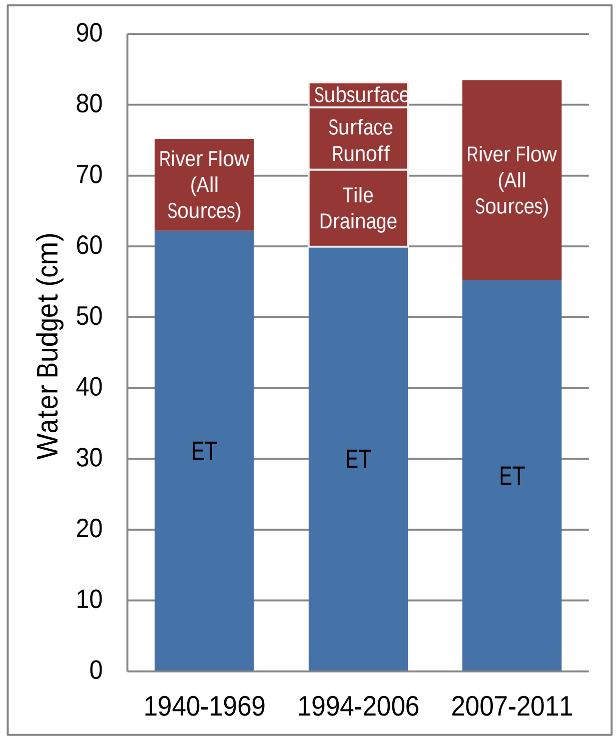


Figure 8: The annual precipitation between mid-20th century and recently has increased (represented by the total height of each bar). Precipitation either flows out of the watershed in rivers (red) or evapotranspirates back into the atmosphere (blue). Water that reaches the river comes from several sources, the largest of which is tile drainage. Refer to adjacent text for data sources and details.

The Le Sueur River's flow has roughly doubled over the past 60 years. Observed river data and subsequent water budget analyses illustrate the increase in river flow between mid-20th, late-20th, and early-21st centuries (Figure 8) (data sources, respectively: USGS, 1974; Folle 2010; and USGS 2014b). Between periods, the runoff ratio (or percent of precipitation that is river flow) increases from 17% to 28% to 34%. This increased river flow corresponds to increased precipitation coupled with decreased ET. The ET calculations assume that over a multiple year period, the effect of ground water interaction on the water budget can be ignored.

A substantial amount of river flow originates from tile drainage: based on Folle's analysis (2010), roughly half of the river flow originated as tile drainage. This analysis shows that 13% of all precipitation in the watershed moves through the tile drainage system and into the river. Moreover, edge-of-field Discovery Farms data from March 2011-September 2013 (Figure 10) documented that 22% of precipitation that fell on the field moved through the tile drainage system to its ravine outlet. A portion of precipitation leaves the field as tile drainage or surface runoff and can be quickly routed to rivers and lakes through the extensive network of drainage.

The increase in the Le Sueur River's flow is due to hydrologic alterations made by both humans (including installing artificial drainage and changing crop types) and the climate (increased precipitation and temperatures). Several studies identify human changes as the primary cause and climatic changes as the secondary cause of this increased river flow.

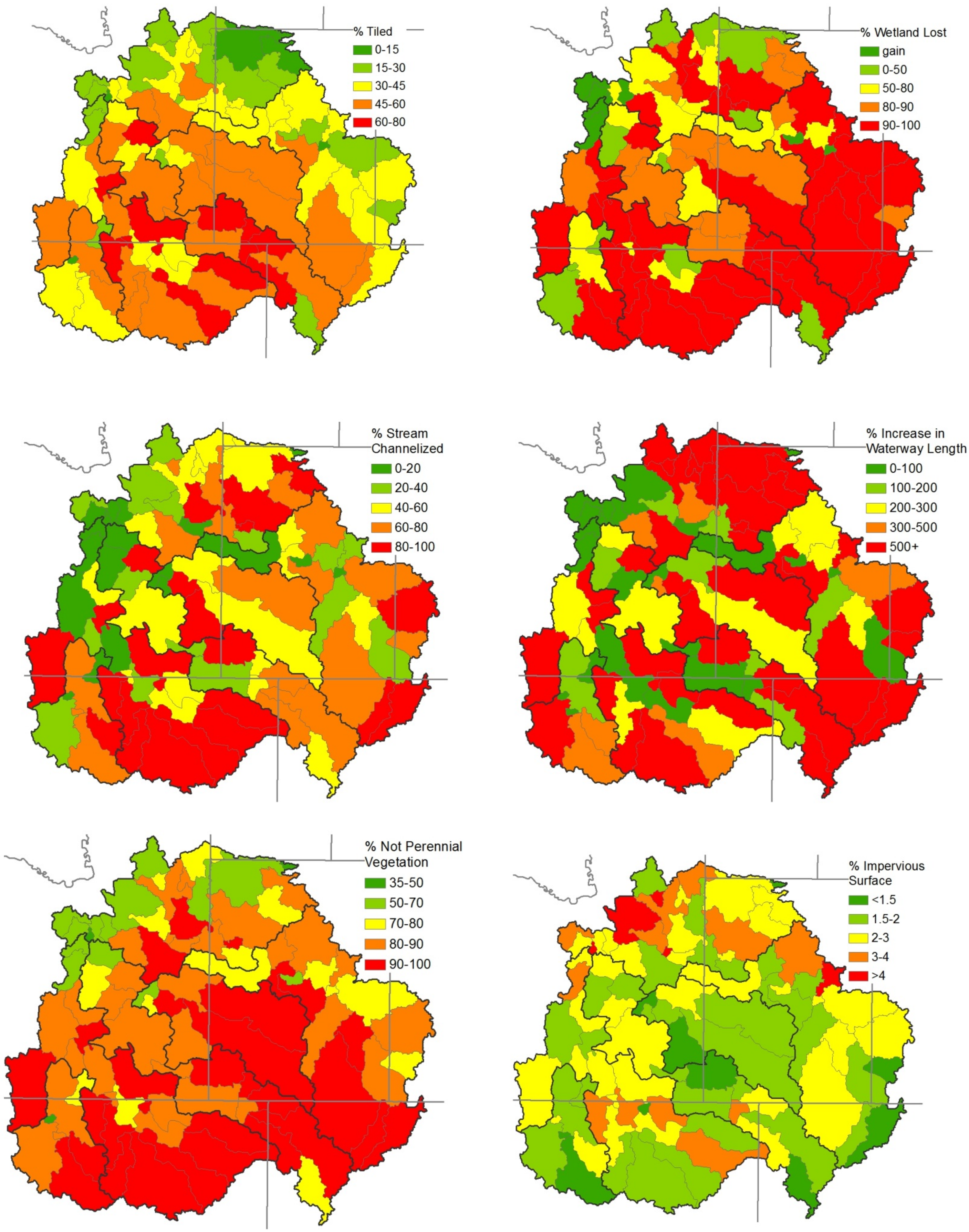


Figure 9: GIS analyses of the Le Sueur River watershed indicate substantial changes to the natural hydrology of the watershed. Subwatershed areas in red indicate the most change in each parameter while those in green indicate less change. See Appendix 6.13 for an example of how these layers can be combined to prioritize subwatersheds to implement strategies that address altered hydrology.

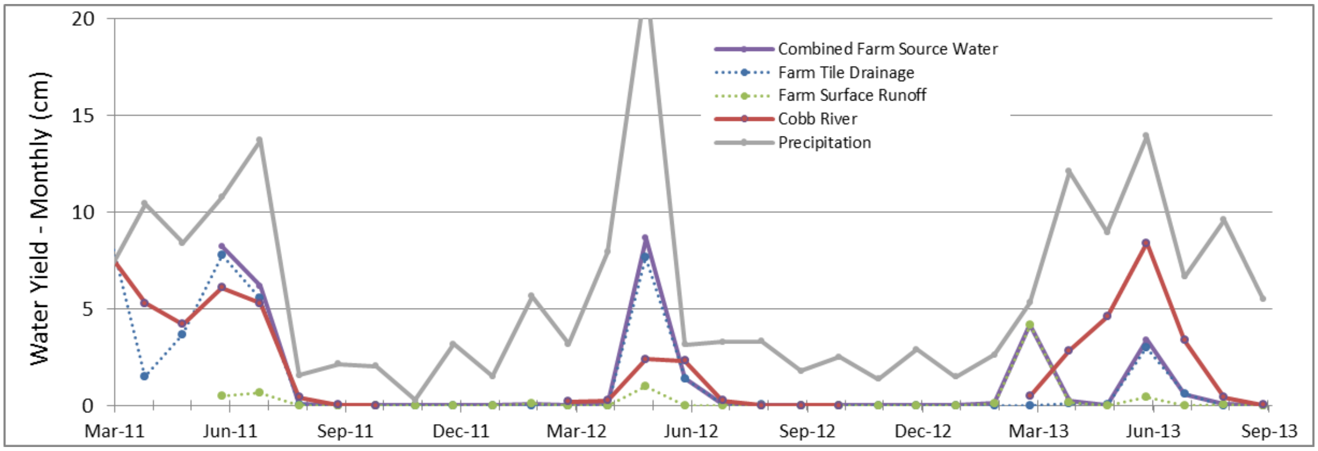


Figure 10: Discovery Farm data reflect water budget analyses and illustrate how tile drainage is a substantial source of water draining from the landscape: tile drainage (blue) contributes substantially more than surface runoff (green) to the total farm water contribution (purple). Refer to the strategies table for the recommended strategies to address excessive water yields/altered hydrology. Water yield is dependent on multiple hydrologic parameters including: localized magnitude and intensity of precipitation, soil moisture, vegetation type and growth, flow paths and basins, etc.

A national study: *Quantifying the Relative Contribution of the Climate and Direct Human Impacts...* (Wang & Hejazi 2011) found that over 60% of the mid- to late-20th century increase in the Le Sueur River's flow was caused by human changes. A study of Minnesota watersheds: *Twentieth Century Agricultural Drainage Creates More Erosive Rivers*, (Schottler et al.2013) similarly found that human changes, including drainage and crop changes, were the primary cause of mid- to late-20th century increased river flows (Figure 11).

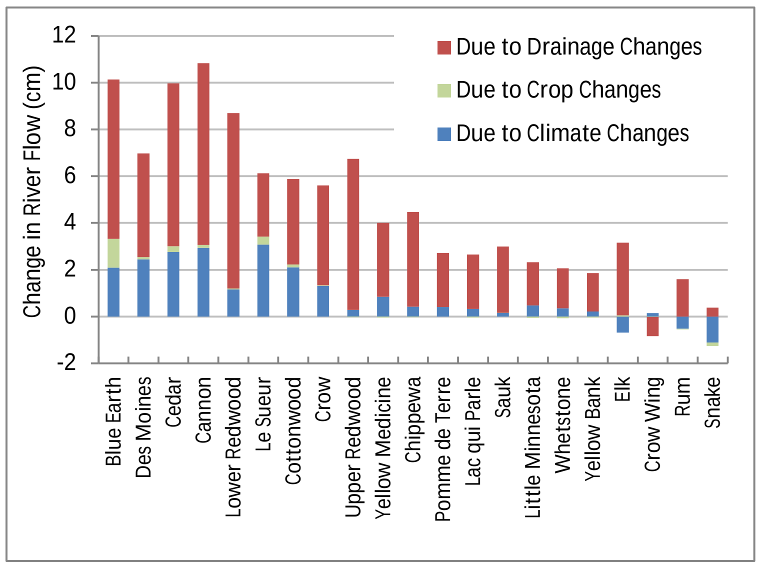


Figure 11: Schottler et al. (2013) estimated that in agriculturally-dominated watersheds in Minnesota, more than 50% of the increase in river flow between the mid and late 20th century was caused by changes in agricultural drainage.

Other studies suggest the relative role of these causes may be reversed. For instance, Nangia, Mulla, and Gowda (2010) suggest: *Precipitation Changes Impact Stream Discharge... More than Agricultural Management Changes*. However, multiple lines of evidence converge upon human changes having a considerable impact on increased river flow; therefore, this form of altered hydrology cannot be considered substantially natural. Furthermore, this watershed cannot improve without substantial mitigation of altered hydrology.

In addition to high river flow, altered hydrology exhibited in excessively low river base flow is an identified stressor in the Le Sueur River watershed. These low base flow conditions have been conclusively linked to low DO conditions in at least one river reach (as discussed in the Le Sueur River watershed TMDL (MPCA 2015)) but likely have additional consequences to aquatic life (as discussed in the Stressor ID Report (MPCA 2014c)). Base flow is sustained by shallow groundwater and interflow. Simply put, low base flow is indicative of soils being too dry and water tables being too low – partly the result of draining excess water from the landscape. Therefore, these sources are unable to deliver ample water to rivers at dry times of year, when base flow is the only source of river flow.

Sediment

The Le Sueur River Watershed is a prolific source of total suspended solids (TSS) which affects downstream waters including the Minnesota River and Lake Pepin. The watershed has geologic properties (as discussed in Section 2) that make it susceptible to high erosion; however, the altered hydrology within the watershed has exacerbated sediment loadings – unnaturally high river flows accelerate river bank/bluff erosion. For instance, in *An Integrated Sediment Budget for the Le Sueur River Basin*, Gran et al. (2011) estimate the sediment production of the watershed to be 400-500% more today than it was pre-European settlement.

Le Sueur River Watershed sediment sources are almost exclusively from non-point sources. For years 2007-2011, point sources accounted for approximately 0.02% of the total TSS load (49,000 kg of 216 million kg). Even in the low flow year of 2009, point sources accounted for only 0.08% of the load. Due to this very low percentage, point source contributions of sediment do not require reductions.

The three non-point source contributors of sediment include: 1) channel sources: bluffs, banks, beds, and floodplains, 2) ravines and gullies, and 3) uplands. These sources have been proportioned in several studies (Table 4). Source proportions for HSPF modeling within the Le Sueur River Watershed were based on the source proportioning as determined by Gran et al. (2011).

Table 4: Different methodologies applied to different data sets have resulted in multiple sediment sources proportions. Overall, channel sources are recognized as the dominant sediment source in the Le Sueur River watershed.

Estimate By	Watershed	Data Years	Summarized Method	Channel	Ravine	Upland	Notes
Sekely, Mulla, & Bauer, 2002	Greater Blue Earth	1997-2000	bluff survey	37%			Bluff only, but stated other channel contributions "rare"
Baskfield, 2008	Maple River	2006-2007	source estimates, curve regression	60%	21%	19%	Author suspects channel component overestimated
Folle, 2010	Le Sueur	1994-2006	SWAT modeling			21%	Model can estimate upland sources only
Gran et al., 2011	Le Sueur	2000-2010	sediment budget	65%	9%	26%	Multiple analyses used to corroborate budget analysis

Discovery Farms data show average (flow-weighted mean) TSS concentration of: farm field runoff, tile-drained water, and the combined contributions of the farm field by month (Figure 12). For comparision, the receiving water, the Cobb River, and the river goal are shown. High TSS concentrations in surface runoff typically occur in high precipitation months generally in the spring/early summer (refer back to Figure 10), when there is little plant coverage of field soils. Tile drained water is generally very low in TSS; however, once it reaches a ravine or stream, this water contributes to the force that can cause ravines and river banks to erode.

HSPF model non-point TSS yield estimates by source type are presented in Figure 16. These estimates can be used to target conservation to the highest yielding subwatersheds. Refer to Section 3.4 for more information on HSPF and the model results.

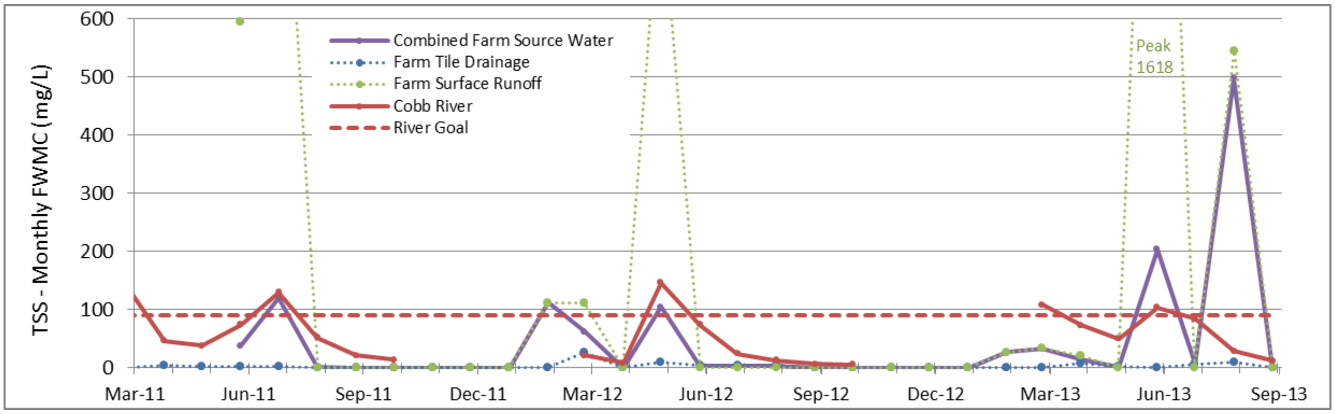
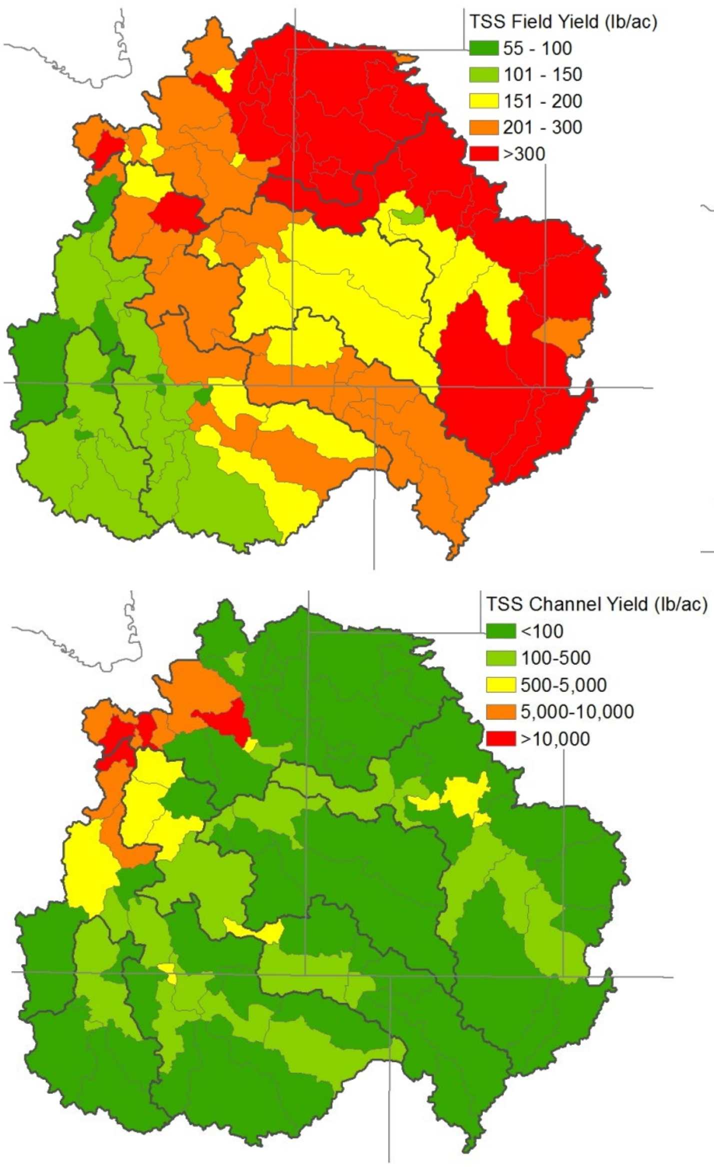


Figure 12: Discovery Farms data illustrate how the river concentration (red) tends to be higher than the combined farm contribution (purple) but follows the same trend. This data corroborates source identification work that finds that farms are a substantial sediment source, but additional and substantial sediment sources also exist. Nearly all farm source sediment is from surface runoff; refer to the Strategies Table for the recommended strategies to address sediment.



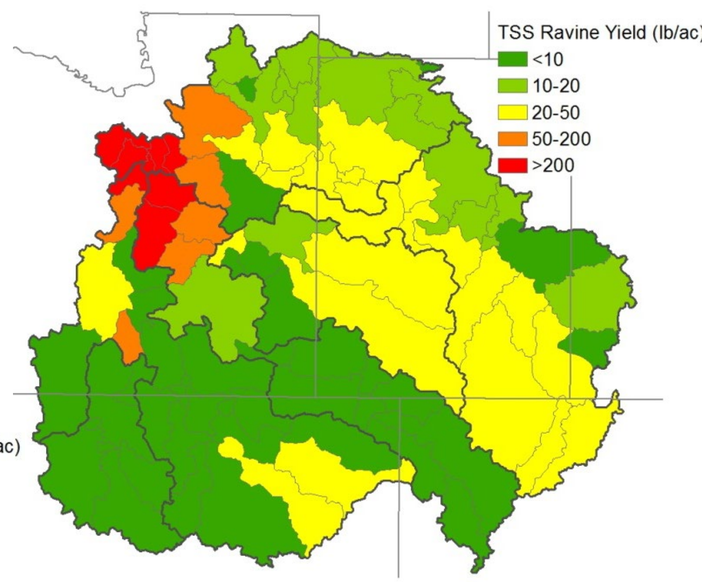


Figure 13: The HSPF-modeled sediment contributions by source type (field/upland, ravine, or channel) highlight areas of the watershed to prioritize the implementation of strategies to reduce sediment. TSS from upland contributions can be managed by strategies that address surface runoff and erosion. Reducing ravine and channel contributions requires that altered hydrology be addressed in the contributing watershed of the streams where these problems exist.

Nitrogen

The MPCA's *[Nitrogen in Minnesota Surface Waters]* report (2013h) estimates nitrogen sources for the Minnesota River basin (Figure 14). In an average precipitation year, agricultural sources account for approximately 90% of TN load to the Minnesota River.

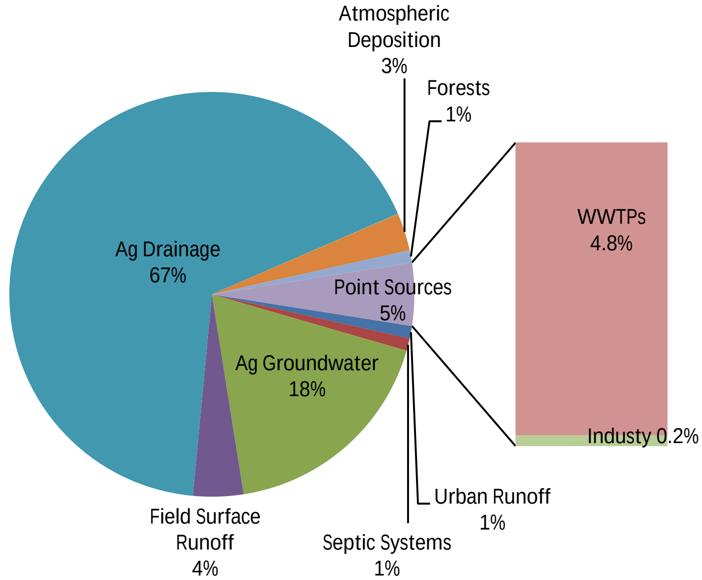


Figure 14: Non-point source estimates for nitrogen for the Minnesota River basin (for an average precipitation year) approximate the sources within the Le Sueur River watershed. While these numbers overestimate the point source contributions, the ratio of these contributions (WWTPs and industrial) was extrapolated from watershed data to match the basin wide point-source percentage.

While these results are for the Minnesota River basin in general, the source proportions are expected to adequately represent the Le Sueur River Watershed. The non-point contributions are likely underestimated because the Le Sueur River Watershed has a higher agriculture land use rate than the basin in general. Additionally, the point source contributions were estimated (by using pollutant loads of similar facilities) to be 1% of the annual average nitrogen load observed at the outlet of the Le Sueur River Watershed (62,000 kg of 7.3 million kg in 2007-2011). Even in the low flow year (when point sources typically have higher impact on the total load) 2009, point sources were still estimated to contribute only 2% of the TN load (47,000 kg of 2.2 million kg). See Appendix 6.11 for point source information.

Discovery Farms data illustrate the nitrogen contributions made by farm fields. Figure 15 shows the nitrite plus nitrate (NOx) concentration of: farm field runoff, tile-drained water, and the combined contributions of the farm field by month. For comparision, the receiving water, the Cobb River, and the river goal are shown. The monthly average NOx concentrations illustrate the seasonal nature of high NOx concentrations. Typically, NOx concentrations in tile drainage water are high throughout the spring and summer. However, since most of the water flowing from the tile drainage system occurs in spring/early summer (refer back to Figure 10), most NOx contributions (by total mass) from tile drainage water occur in the spring/early summer.

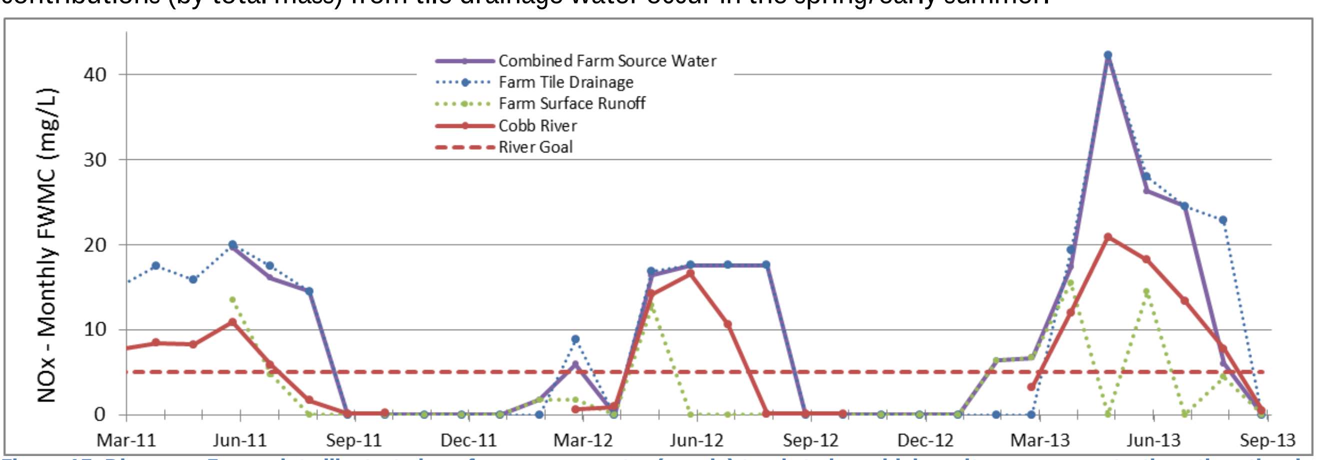
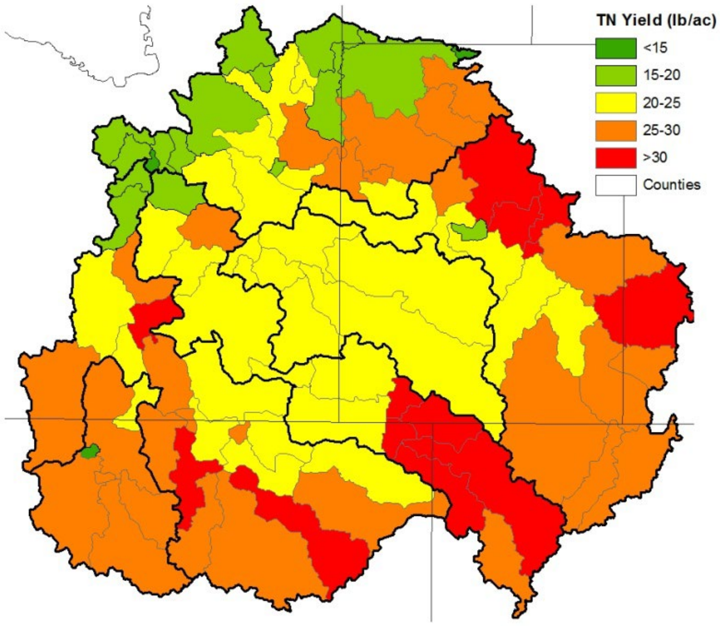


Figure 15: Discovery Farms data illustrate how farm source water (purple) tends to have higher nitrogen concentrations than the river (red) and follows the same trend. Tile drainage water (blue) was generally high in nitrogen, but surface runoff (green) also had intermittent high concentrations. This data corroborates source identification work indicating that tiled-field source water dominates nitrogen contributions. Refer to the Strategies Table for recommended strategies to address nitrogen.

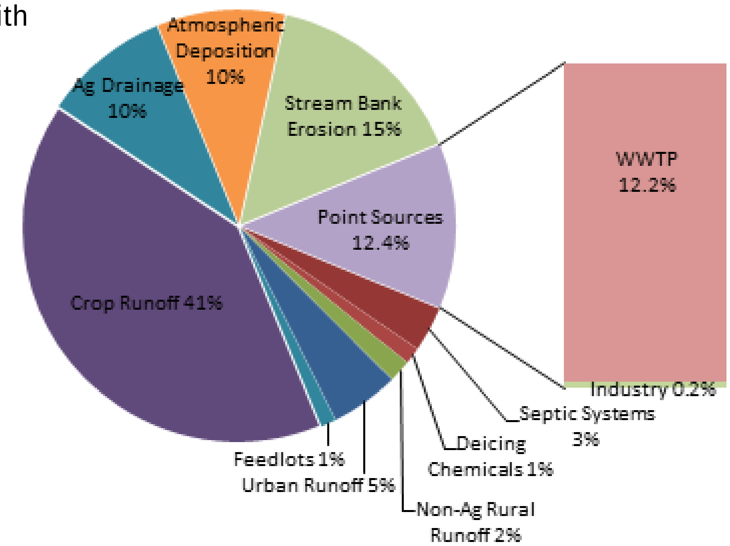


HSPF model non-point TN yield estimates are presented in Figure 16. These estimates can be used to target conservation to the highest yielding subwatersheds. Refer to Section 3.4 for more information on HSPF model results.

Figure 16: HSPF model results indicate that non-point source yields of total nitrogen are highest near the East, South, and Southwest portions of the watershed perimeter. Targeting and implementing nitrogen-reducing strategies in these areas will decrease both the nitrogen concentrations of waters in these and downstream areas and will also decrease the total nitrogen produced by the watershed.

Phosphorus

Barr Engineering and the MPCA's *Detailed Assessments of Phosphorus Sources to Minnesota Watersheds* report (2003 with 2007 update) identifies sources of TP by major basin. In the Minnesota River basin, in an average precipitation year, roughly half of the phosphorus load to surface water is directly from agricultural runoff and tile drainage (combined), with additional significant contributions from stream bank erosion, point sources, and atmospheric deposition (Figure 17).



Similar to nitrogen, the basin-wide souce proportions are expected to adeqately represent the Le Sueur River Watershed. Nonpoint contributions may be underestimated because the Le Sueur River Watershed has a higher agriculture land use rate than the basin in general and because wastewater treatment plants (WWTPs) have improved phosphorus removal efficiency (and one high loading WWTP, Madison Lake, discontinued use). Point sources contributed 2% of the average annual TP observed at the outlet of the Le Sueur River Watershed (7,000 kg of 312,000 kg in 2007-2011). Even in the low flow year (when point sources typically have higher impact on the total load) 2009, point sources contributed 6% of the total load (5,400 kg of 91,000 kg). See Appendix 6.11 for point source information.

Figure 17: Non-point source estimates for phosphorus for the Minnesota River basin (for an average precipitation year) approximate the sources within the Le Sueur River watershed. While the point source contributions are overestimates, the ratio of these contributions (WWTPs and industrial) was extrapolated from watershed data to match the basin wide point-source percentage.

Discovery Farms data illustrates the TP contributions made by farm fields. Figure 15 shows the TP concentration of: farm field runoff, tile-drained water, and the combined contributions of the farm field by month. For comparision, the receiving water, the Cobb River, and the river goal are shown. The monthly average TP concentrations illustrate the seasonal and rain-driven nature of high TP concentrations. Typically, high surface water TP concentrations occur in months with high rainfall amounts (refer back to Figure 10) or snow melt. Under certain conditions, however, TP concentrations can be high in tile drainage water.

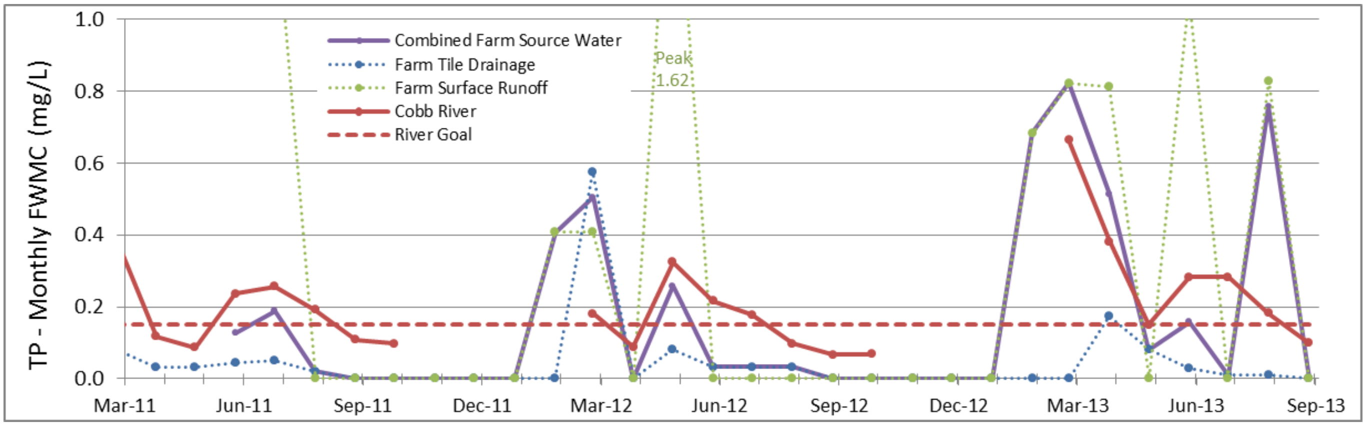


Figure 18: Discovery Farms data illustrate how farm source water (purple) tends to have lower phosphorus concentrations than the river (red) in times of less surface runoff, but at times of high surface runoff, this relationship can reverse. Generally, more phosphorus is from surface runoff (green); however, tile drainage (blue) is also a contributor. These data corroborate source identification work that farm source water is a substantial, but not exclusive, source of phosphorus.

HSPF model non-point TP yield estimates are presented in Figure 19. These estimates can be used to target conservation to the highest yielding subwatersheds. Refer to Section 3.4 for more information on HSPF and the model results.

Phosphorus sources to lakes are discussed in the Le Sueur River Watershed TMDL (MPCA 2015) and the Lakes Report (MPCA 2010). Similar to the phosphourus source proporitons reported above, field runoff is generally the largest contributor. Internal contributions (from re-suspension of lake-bottom sediment) are suspected to be high for a few lakes. Smaller contributions are estimated to be delivered from septic systems and impervious surface runoff.

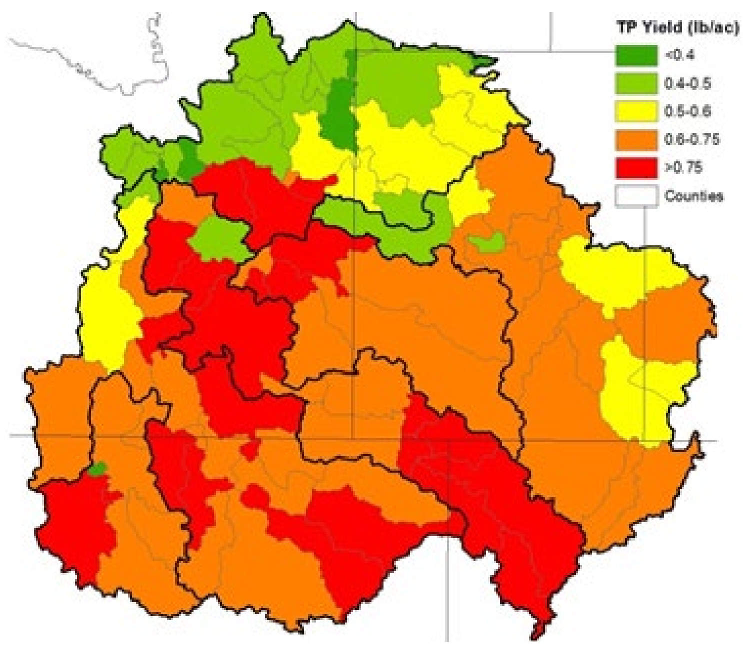


Figure 19: HSPF model results indicate that non-point source yields of total phosphorus are generally highest in the central and southern portions of the watershed. Targeting and implementing phosphorus-reducing BMPs in these areas will decrease the phosphorus concentrations in these and downstream waters and decrease the total phosphorus produced by the watershed.

E. coli /Fecal Coliform

Fecal bacteria source identification is difficult due to the dynamic and living attributes of bacteria. Emmons & Olivier Resources (2009) conducted a *Literature Summary of Bacteria* for the MPCA. The literature review summarized factors that have either a strong or weak positive relationship to fecal bacterial contamination in streams (Table 5).

Fecal bacteria source identification is further confounded because some bacteria may be able to survive and reproduce in streams as found in *Growth, Survival… of E. coli…* (*Sadowsky et al*. 2010). This study traced substantial numbers of bacteria to cattle sources, while no samples could be traced to human sources. Because there is currently a lack of ample study on in-stream reproduction and fecal bacteria pose significant risks to human health, the percent of the bacterial load attributed to this source is conservatively estimated at zero for this analysis. Instead, the source identification in the EPA-approved *Fecal Coliform TMDL Assessment for…the Blue Earth River Basin* (WRC 2007) is the basis of bacterial source identification in the Le Sueur River Watershed.

Table 5: Bacteria sourcing can be very difficult due to the bacteria's ability to persist, reproduce, and migrate in unpredictable ways. Therefore, the factors associated with bacterial presence provide some confidence to bacterial source estimates.

Strong relationship to fecal bacterial contamination in water	**Weak** relationship to fecal bacterial contamination in water
· High storm flow (the single most important factor in multiple studies) · % rural or agricultural areas greater than % forested areas in the landscape (entire watershed area) · % urban areas greater than % forested riparian areas in the landscape · High water temperature · Higher % impervious surfaces · Livestock present · Suspended solids	· High nutrients · Loss of riparian wetlands · Shallow depth (bacteria decrease with depth) · Amount of sunlight (increased UV-A deactivates bacteria) · Sediment type (higher organic matter, clay content and moisture; finer-grained) · Soil characteristics (higher temperature, nutrients, organic matter content, humidity, moisture and biota; lower pH) · Stream ditching (present or when increased) · Epilithic periphyton (plants and microbes that grow on stones in a stream) present · Presence of waterfowl or other wildlife · Conductivity

This TMDL estimates sources of fecal coliform based on the production of fecal coliform in the watershed and an estimated delivery ratio. While 99% of fecal coliform is produced by domesticated farm animals according to the TMDL, the sources of fecal bacteria are not numerically proportioned. Figure 20 was constructed based on numbers in that report but is only intended to roughly estimate the source proportions.

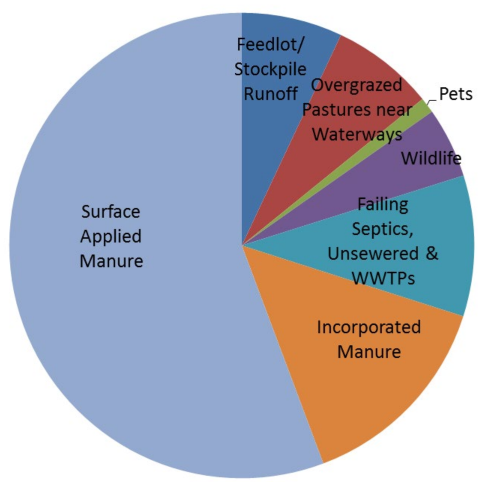


Figure 20: An estimate of fecal coliform source proportions in the Le Sueur River watershed is based on assumptions from the Blue Earth River fecal coliform TMDL.

Dissolved Oxygen (DO)

Low DO in water bodies is caused by: 1) excessive oxygen use (for example, caused by decay of dying algae) and/or 2) too little re-oxygenation (for example, caused by minimal turbulence or high water temperatures). For at least one of the reaches where low DO was found to be a pollutant and/or stressor (Little Cobb River), HSPF modeling indicates that low base flow is a primary cause of this stressor. Excessively low base flow does not have enough velocity to create turbulence to oxygenate the water. The situation is further exacerbated in this watershed because over-widened channels allow a larger cross-sectional area for base flow to move at even lower velocities and come to higher temperatures.

Habitat

Poor habitat affects fish and invertebrate populations by reducing the amount of suitable habitat needed for feeding, shelter, and reproduction. Altered hydrology is the primary cause of degraded habitat throughout the watershed; changes in the connectivity, timing, and amount of flow have created stream instability, vegetation loss, and reduction or elimination of floodplain connectivity. Additional habitat concerns in the watershed include degraded riparian conditions, including loss of riparian vegetation.

Connectivity

In this case, connectivity refers to the longitudinal connectivity of the stream (or pathway as the stream travels downstream). Lack of connectivity was identified as a stressor on one stream reach (CD 6). The cause of the lack of connectivity in CD6 was identified as the manmade water control structure downstream from Lake Elysian.

4.2 Water Quality Goals

Water quality goals aim to: 1) enable water bodies within the watershed to meet the water quality standards and therefore, their designated use and 2) enable downstream waters to meet water quality goals (e.g. Lake Pepin and Gulf Hypoxia goals). Long term "goals" are achievable but can seem unreachable and idealistic. For this reason, "10-year targets" are set and allow opportunities to adaptively manage implementation efforts. The goals and 10-year targets are presented in Table 6. Refer to Appendix 6.5 for information on the goals. The 10-year targets were developed by the Strategies Development Team (see Section 5 for clarification). The priority sources are based on the source identification work summarized in Section 4.1.

For now, efforts should focus on the 10-year targets rather than the goals; the 10-year targets represent a first step towards the goals. Furthermore, the goals were calculated with a specific data set, will be recalculated with new data in future iterations of the Watershed Approach, and are subject to change based on possible new water quality standards or state-wide goals.

Table 6: The goals are the estimated change in pollutant/stressor needed for watershed and downstream waters to meet water quality goals. The 10-year targets, set by local conservation professionals, represent the portion of the goal targeted to address in the next 10 years by implementing the strategies presented in Table 8.

	Pollutant/Stressor	Goal	10-year Target	Priority Source(s)	10-year Target Portioned to Source(s)
Watershed-wide	Excessively High River Flow, Including Peak Flows	25% ↓	5% ↓	Human-altered hydrology: decreased ET and storage due to vegetation, land use, and drainage changes	5% ↓
	Excessively Low River Base Flow	Increase	Increase	Human-altered hydrology: low water table, infiltration, and soil moisture due to vegetation, land use, and drainage changes	Increase
	High TSS Concentrations	65% ↓	10% ↓	Bank/bluff erosion	4% ↓
				Upland/field erosion	4% ↓
				Ravine/gully erosion	2% ↓
	High TN Concentrations	45% ↓	12% ↓	Ag tile drainage and ground water	12% ↓
	High TP Concentrations	60% ↓	10% ↓	Field surface runoff	4% ↓
				Bank/bluff erosion	2% ↓
				Tile drainage water	4% ↓
	High E. coli Concentrations	50% ↓	27% ↓	Manure-treated ag field surface runoff	17% ↓
				Improperly treated human sewage	10% ↓
	Poor Habitat	Improve	Improve	Degraded riparian	Improve
				Altered hydrology & High TSS	see above
Lake Watersheds - High TP concentration		60% ↓	10/15% ↓	Field surface runoff, malfunctioning septic systems, and tile drainage	10/15% ↓
Cities - Non-point contributions		↓	5% ↓	Stormwater runoff: impervious surfaces, constructions sites, etc..	5% ↓

5. Restoration & Protection

{How do we cleanup the waters?}

This section summarizes civically-supported strategies and scientifically-supported strategies to restore and protect waters within the Le Sueur River watershed. Based on these strategies, the condition and pollutant source identification work, and professional judgment, a team of local and state conservation and planning staff (referred to as the "Strategies Development Team") selected restoration and protection strategies to meet the 10-year water quality targets. See list of Strategies Development Team members inside front cover.

Using the selected restoration and protection strategies, local conservation planning staff can prioritize areas and spatially target specific BMPs or land management strategies using GIS or other tools, as encouraged by funding entities and Clean Water Legacy legislation on WRAPS (ROS 2013).

5.1 Civically-Supported Strategies to Restore and Protect Waters

Communities and individuals ultimately hold the power to restore and protect waters in the Le Sueur River Watershed. For this reason, the Clean Water Council (MPCA 2013e) recommended that agencies integrate civic engagement in watershed projects (MPCA 2010c). This section summarizes four civic engagement/public participation efforts sponsored by the MPCA in collaboration with local partners: 1) Le Sueur River Watershed Network, 2) Lakes Focus Group, 3) Citizen and farmer interviews conducted by SWCD staff, and 4) County water planner and SWCD priorities and challenges.

Le Sueur River Watershed Network

Le Sueur River Watershed Network (2013) is composed of watershed residents, concerned citizens and groups, and resource agency staff. Resulting from a series of meetings that occurred between January and May of 2013, a Citizen Advisory Committee made seven recommendations to improve water quality. The summarized recommendations are in order of the committee's preference:

1. Storm water management and in-ditch storage
2. Experimentation and demonstration with temporary water storage
3. Strategically placed buffers, terraces, and grassed waterways
4. Communication and education for watershed residents
5. Less red tape
6. River channel maintenance of major snags
7. Streambank and ravine stabilization

Lakes Focus Group

A one-time meeting was held in February 2014, to solicit the preferred restoration and protection strategies of citizens who are interested in improving and protecting lakes within the Le Sueur River watershed. The preferred strategies to implement in Lake Watersheds, in order of preference, were:

1. Lake buffers, setbacks, and native/healthy lakescaping
2. Public education/outreach
3. Nutrient management
4. Improved storm/drainage water management
5. Wetland restoration

Resident & Farmer Interviews

The SWCD staff designed and performed interviews with residents in the *Le Sueur River Watershed Priority Management Zone Identification Project* (MPCA 2014f). The objectives of these interviews were to: 1) connect residents and local staff, 2) learn resident opinions and concerns regarding water quality, and 3) provide maps and resources to spur conversations and identify conservation opportunities. Generalized themes from these interviews included:

- Farming has undergone significant changes over the last several decades. A wide spectrum of understanding and interest exists regarding water quality, conservation practices, and sustainable agriculture. Most farmers feel they are doing a good job with conservation, but economics are the largest factor in making agricultural land management choices.
- While many farmers have made some conservation improvements, many more opportunities still exist. For instance, some who practice no-till consider this a competitive edge, but most farmers have (real or perceived) obstacles to using no-till. Several potential projects and obstacles to adopting conservation practices were identified.
- The general public sees a need for increased conservation. In one county, the percent of interviewees that thought the following BMPs should be increased is: 72% increased vegetation, 43% riparian buffers, 29% ponds/wetlands, 21% conservation/sediment control structures, 18% progressive drainage design, 17% river/bank projects, 12% lake shore restoration, and 10% urban storm water BMPs.

Staff-Identified Priorities & Challenges

County SWCD, Water Planning, and Environmental staff works directly with the citizens and natural resources of the watershed. Furthermore, these local staff write locally-focused conservation plans and assist landowners with most of the conservation implementation that occurs. For these reasons, the priorities and challenges to local staff can help state agency and other partners focus state financial and technical resources more effectively. County staff priorities (as submitted by staff) are included with the watershed resident interviews (link above). Summarized staff priorities and challenges include:

- Staff identified priority management areas:
    - Blue Earth - lakes, urban development, bluff, ravine and field erosion, water retention and wetland restoration
    - Waseca - demonstration sites including: wetlands, floodplain easements, and stream restoration sites
    - Faribault - drainage watershed approach using a redetermination of benefits
    - Freeborn - lake and stream restoration, wetlands, water retention/infiltration, vegetative buffers
- More technical and financial resources should be provided to improve SWCD operations. Limited numbers of staff and turnover is a problem due to inconsistent funding, resulting in loss of producer rapport and significant time put into training new staff.
- Local staff must balance the sometimes conflicting interests of citizens, agencies, and local boards. More state level support is needed to protect water resources. State agencies could improve their organization and effectiveness communicating with local staff. The scale of programs/boundaries should be well-planned and flexible to meet local needs.

5.2 Scientifically-Supported Strategies to Restore and Protect Waters

This section summarizes studies and data on land management and best management practice (BMP) effects on water quality. This information is more technical in nature, but these summaries may be helpful to landowners, decision makers, and citizens to understand the impact of various strategies and BMPs on water quality.

Agricultural BMPs

Since the Le Sueur River Watershed and pollutant source contributions are generally dominated by agriculture, reducing pollutant/stressor contributions from agricultural sources is a high priority. A comprehensive resource for agricultural BMPs is the *The Agricultural BMP Handbook for Minnesota* (Miller et al. 2012). Hundreds of field studies of agricultural BMPs are summarized in the handbook, which has been summarized in Appendix 6.1. This summary table also contains a "relative effectiveness", which was estimated by conservation staff. For clarifications, the reader should reference the handbook.

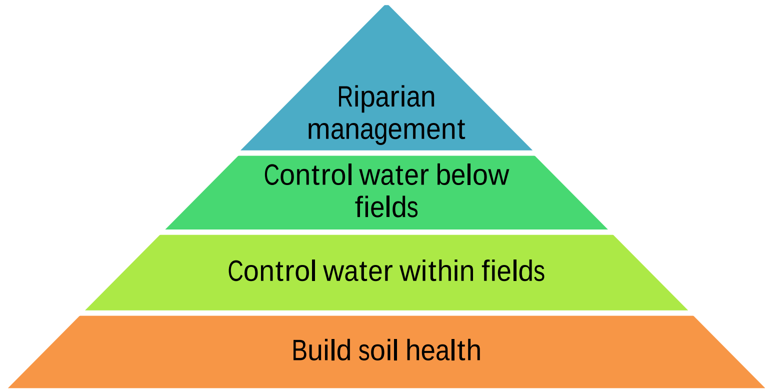


Figure 21: To address the widespread water quality impairments in agriculturally-dominated watersheds such as the Le Sueur River watershed, an integrated and multi-faceted approach using suites of BMPs is likely necessary. Several models/methods have been developed and are very similar including the model pictured here (Tomer et al., 2013), the Minnesota Nutrient Reduction Strategy (PCA, 2013i), and the "Treatment Train" approach as being demonstrated in the Elm Creek Watershed (ENRTF, 2013).

A Minnesota River Valley Ravine Stabilization Charrette (E&M 2001) was convened and included several local engineers and scientists familiar with ravine stabilization strategies. The authors note that the group favored addressing hydrology to control ravine erosion. The provided link summarizes the findings and recommended strategies to address ravine sediment contributions.

Stormwater Management BMPs

Cities and watershed residents also have a significant impact on water quality. A comprehensive resource for urban and residential BMPs is the *Minnesota Stormwater Manual* (MPCA 2014b). This resource is in electronic format and includes links to studies, calculators, special considerations for Minnesota, and links regarding industrial and stormwater programs.

Lake Watershed Strategies

To protect and restore lakes, strategies should minimize relative pollutant contributions from the watershed, shoreland development, and in-lake (Appendix 6.8). Strategies to minimize pollutant contributions from the watershed focus mostly on Agricultural and/or Stormwater BMPs, depending on the land use and pollutant contributions of the watershed. The DNR (2014) supplies detailed information on strategies to implement on the shoreland and in the lake via Shoreland Management guidance.

Computer Model Results

Computer models provide a scientifically-based estimate of the pollutant reduction effectiveness of land management and BMPs. Models represent complex natural phenomena with equations and numeric estimates of natural features, which can vary substantially between models. Because of these varying assumptions and estimates, each model has its strengths and weaknesses and can provide differing results. For these reasons, multiple model results were used as multiple lines of evidence by the Strategies Development Team. The table presented in Appendix 6.2 summarizes five model analyses of the Le Sueur River Watershed or other similar watersheds. The reader is encouraged to refer to the linked reports (in table) for more details.

5.3 Selected Strategies to Restore and Protect Waters

As previously discussed, data and models indicate that comprehensive and integrated BMP suites (Figure 21) are likely necessary to bring waters in the Le Sueur River Watershed into supporting status (refer to models summarized in 6.2 for an idea of the scale of adoption necessary to bring all waters in to supporting status). However, civic engagement work illustrates that there are current limitations in BMP adoption and some technologies are not yet feasible. For these reasons, recommending suites of strategies capable of cumulatively achieving all water quality goals is not practical and would likely need substantial future revision. Rather, restoration and protection strategies to meet the 10-year targets were developed by the Strategies Development Team. Focusing efforts on strategies and adoption rates to meet these water quality targets is more practical. With the next iteration of the watershed approach, progress towards these targets can be assessed and new targets for the following decade can be created.

In the presented Strategies Table (Table 8), pollutant/stressor-specific suites of strategies apply watershed-wide; because 83% of the watershed is in agricultural lands, these strategies apply mostly to agricultural lands. However, there are additional suites of strategies specifically for cities/residents and lake watersheds, since these locations have specialized concerns and opportunities. Refer to map in Appendix 6.5 for watershed areas that apply to each strategy suite.

To improve and protect water quality conditions within and downstream of the Le Sueur River Watershed, strategies need to be implemented across the watershed. However, the adoption rates in any one region will not necessarily match the watershed-wide new adoption rates due to regional differences. Furthermore, not all strategies are appropriate for all locations. The strategies and regional adoption rates should be customized based on locally-led prioritizing and targeting work (see description below).

Protection Considerations

Water bodies that meet water quality standards should be protected to maintain or improve water quality. Furthermore, water bodies that have not been assessed should not be allowed to degrade. Three water bodies were assessed as supporting water quality standards: one reach of the Cobb River, Reeds Lake, and St. Olaf Lake. Several other water bodies have not yet been assessed. The strategies presented in Table 8 are intended to not only restore but also protect waters in the watershed.

Similar to customizing regional adoption rates of the watershed-wide strategies, strategies and adoption rates should reflect the relative amount of protection needed and any site-specific considerations. St. Olaf Lake currently meets standards but has a declining trend. Via lake modeling and other watershed evidence on current phosphorus loading, the 10-year target lake watershed phosphorus load reduction of 10% is acceptable. Reeds Lake is also currently meeting water quality standards but has an improving water quality trend, exemplifying how changes in the watershed can improve water quality conditions. Assuming this improving trend continues, little additional strategy adoption is needed; however, the changes that induced this improving water quality trend (i.e. increased perennial vegetation, wetland restoration, nutrient management, etc.) must be maintained.

The Cobb River reach is currently attaining aquatic life standards likely due to the slope of the stream. The slope is enough to flush excess sediment out of the reach before it impacts aquatic life. Since this reach is in the downstream portion of the subwatershed, implementing strategies in upstream portions of the subwatershed and minimizing degrading impacts will ensure this stream reach continues to support aquatic life.

Prioritizing and Targeting

The objective in "prioritizing" and "targeting" is to identify locations to cost effectively implement practices to achieve the greatest improvement in water quality. A third concept, particularly related to funding, is "measuring", which means that implementation activities should produce measurable results. Figure 22 (BWSR 2014) visually represents these concepts.

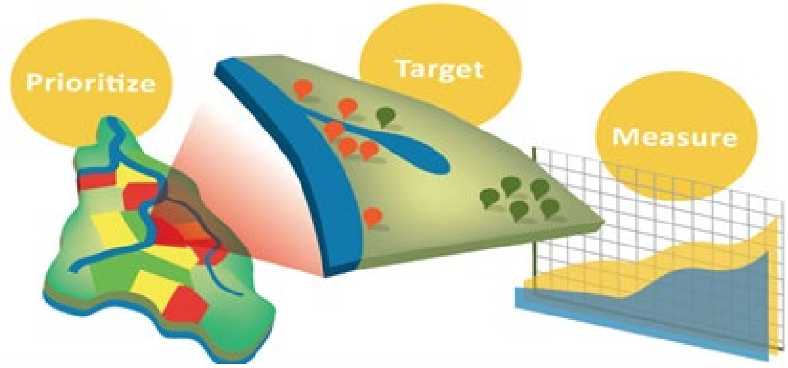


Figure 22: "Prioritized, targeted, and measurable" strategies and plans are more likely to improve water quality and have a better chance to be funded compared to those that are less strategic.

"Prioritizing" refers to the process of selecting priority areas or issues based on a justified water quality, environmental, or other concern. From a state-wide perspective, the Le Sueur River Watershed may be considered high priority because of its high loading of pollutants (refer to Figure 4). Within the Le Sueur River watershed, several prioritization criteria are identified in this report (Table 7). Priority areas within the watershed can be further refined by using these or other criteria either individually or in combination. Additional priority area selection criteria may include: other water quality, environmental, or conservation practice effectiveness models or concerns; ordinances and rules; areas to create habitat corridors; areas of high public interest/value; and many more that can be selected to meet local needs.

Table 7: Priority areas are identified throughout this WRAPS report. Priority areas should be further customized and focused during local planning efforts.

Priority Areas	Refer to
Impaired streams and lakes (subwatersheds) including the type and number of associated impairment parameters and stressors	Table 1, Table 3, Figure 5
Lake subwatersheds with declining trends	Table 1
High loading HSPF-modeled subwatersheds	Figures 13, 16, 19
Highly hydrologically-altered subwatersheds	Figure 9

"Targeting" refers to the process of strategically selecting locations on the land (within a priority area) to implement strategies to meet water quality, environmental, or other concerns (that were identified in the prioritization process). The WRAPS report is not intended to target practices; rather, the work done as part of the larger Watershed Approach should empower local staff to apply their current skill sets to target practices that satisfy local needs.

In a collaborative effort between the MPCA staff and the MSU Waters Resource Center GIS staff, a "Spatial Targeting Workshop" was held for local conservation professionals to identify and practice using GIS spatial targeting tools. Local staff was provided spatial data from the WRAPS report to use in prioritizing and targeting efforts. Resulting from that workshop, multiple resources to assist in prioritizing and targeting efforts were created for and by local staff (two are provided in Appendices 6.3 and 6.4). Further efforts on spatial targeting will be carried forward by the "GBERBA GIS User Group" and by the Water Resource Center staff via a "Targeted Conservation Practices" MPCA grant. Spatial targeting should be further completed by local staff using a combination of tools, personal contacts with land managers, and field verifications.

Table 8: Le Sueur River Watershed Restoration and Protection Strategies Table. See definitions and explanations on page 30.

Pollutant/ Stressor	Goal	Years to Goal	10-year Target	Priority Source(s)	10-year target for source	Restoration and Protection Strategies to meet 10-year target see notes on page 30	Scale of Adoption: % of watershed to newly adopt strategy*	Scale of Adoption: New adoption (in treated acres*)	Responsibility & Role see key on page 30 — Local: Farmers	Local: Residents	Local: GBERBA	Local: Cities	Local: Conservation Groups	Local: Lake Associations	Local: Citizen Network	Local: Crop Consultants	County: SWCD	County: Drainage Authority	County: P&Z or Env. Service	County: Feedlot staff	County: Boards & Supervisors	State: PCA	State: BWSR	State: MDA	State: DNR	State: MDH	State: Legislators	State: DOT	Federal: NRCS	Federal: Fish & Wildlife	Federal: Legislators
Altered Hydrology: High River Flow, including Peak Flow	**25% reduction** in annual flow (including reduced peak flows)	50	**5% reduction**	Human-altered hydrology: decreased ET due to vegetation, land use, and drainage changes	**5%**	Conservation tillage (no-till or strip till w/ high residue)	10.0%	71,000	X		!			#	#	X	X$				!	!	!	!			!		X$		!
						Cover crops	4.0%	28,000	X		!		#	#	#	X	X$				!	!	!	!	#		!	X	X$		!
						Water and sediment basins, terraces *	2.5%	18,000	X		!			#	#		X$	X			!	!	!	!			!		X$		!
						In/near ditch retention and treatment *	2.5%	18,000	X		!				#		X$	X$#			!		!		!		!	X!	X$		
						Conservation cover (easements & buffers of native grass & trees, pollinator habitat)	2.4%	17,000	X	X	!	X	X$#	#	#		X$	X					!$	!	!		!		X$	!$	!
						Grassed waterways *	2.0%	14,000	X		!		#	#	#	X	X$				!	!	!	!			!	X	X$		!
						Saturated buffers *	1.5%	11,000	X		!		#	#	#		X$	X			!		!	!	!		!		X$		!
						Tile system design and use for controlled/less drainage	1.0%	7,100	X		!						$	#					!								
						Treatment wetlands *	1.0%	7,100	X		!	X$	#	#	#		X$	#			!	!	!	!	!	!	!		X$		!
						Restored wetlands	0.2%	1,400	X		!	X$	X$#	x#	#		X$	X#			!	!	!$		!	!	!	X!	X$	X$!	!
						Reexamine and revise drainage law	n/a		#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	#	X	#	#	#	#
Altered Hydrology: Low River Base Flow	**Increase** dry season base flow (no specific numeric goal)	50	**increase** (no numeric goal yet)	Human-altered hydrology: low water table, infiltration, and soil moisture due to vegetation, land use, and drainage changes	**increase**	Conservation cover	>10% of adoption rates for reducing flow should be targeted to also increase flow in areas with low base flow related impairments		X	X	!	X	X$#	#	#		X$	X					!$	!	!		!		X$	!$	!
						Restored wetlands			X		!	X$	#	x#	#		X$	X#			!	!	!$		!	!	!	X!	X$	X$!	!
						Cover crops (best coupled with conservation tillage)			X		!		#	#	#	X	X$				!	!	!	!	#		!	X	X$		!
						In/near ditch retention and treatment *			X		!				#		X$	X$#			!		!				!	X!	X$		
High Sediment (TSS) Concentrations	**65% reduction** in multi-year FWMC (from 365 to 90 mg/L)	65	**10% reduction**	Bank/bluff erosion	**4%**	Strategies to reduce flow (see above)	see above		see above																						
						Streambank stabilization	to protect high value property		X	X	!	X	$		#		X$	X							X!$			X$	X$		
						Livestock exclusion	25% of grazed riparian areas		X				$	#	#		X$		X#	X#	!	!$	!$		X		!		X$		
				Upland/ field surface runoff	**4%**	Field buffers, borders, and/or filter strips *	10.0%	71,000	X	X	!	X	#	#	#	X	X$	X#	X	#	#!	$	$	!	#		!		X$		
						Conservation tillage (no-till or strip till w/ high residue)	10.0%	71,000	X		!			#	#	X	X$				!	!	!	!			!		X$		!
						Cover crops	4.0%	28,000	X		!		#	#	#	X	X$				!	!	!	!	#		!	X	X$		!
						Water and sediment basins, terraces *	2.5%	18,000	X		!			#	#		X$	X			!	!	!	!	!		!		X$		!
						In/near ditch retention and treatment *	2.5%	18,000	X		!				#		X$	X#			!		!				!	X!	X$		
						Conservation cover easements	2.2%	16,000	X	X	!	X	X$#	#	#		X$	X					!$	!	!		!		X$	!$	!
						Grassed waterways *	2.0%	14,000	X		!		#	#	#	X	X$				!	!	!	!			!	X	X$		!
				Ravine erosion	**2%**	Strategies to reduce flow- some of flow reduction strategies should be targeted to ravine subwatersheds			see above																						
						Ravine (grade) stabilization - Target ravine subwatersheds where hydrology has been addressed but erosion substantial			X	X	!	X$			#		X$		X		#	!$	!$	!	!		!		X$		
High Nitrogen (TN) Concentrations	**45% reduction** in multi-year FWMC (from 9 to 5 mg/L)	38	**12% reduction**	Tile drainage and ground water from ag fields	**12%**	Nutrient management (including manure)/reduced application	20.0%	140,000	X	X	!	X$	#	#	#	X	X$			#	!	!$	!$	!		X!	!		X$		!
						Cover crops (best coupled with conservation tillage)	4.0%	28,000	X		!		#	#	#	X	X$				!	!	!	!	#		!	X	X$		!
						In/near ditch retention and treatment *	2.5%	18,000	X		!		#	#	#		X$	X			!		!	!	!		!		X$		!
						Saturated buffers *	1.5%	11,000	X		!		#	#	#		X$	X			!		!	!	!		!		X$		!
						Woodchip bioreactors *	1.5%	11,000	X		!		#	#	#		X$	X			!		!	!	!		!		X$		!
						Conservation cover (easements/buffers of native grass & trees, pollinator habitat)	2.4%	17,000	X		!		#	#	#	X	X$				!	!	!	!			!	X	X$		!
						Tile system design and use for controlled/less drainage	1.0%	7,100	X		!						$	#					!								
						Treatment wetlands *	1.0%	7,100	X		!	X$	#	#	#		X$	#			!	!	!	!	!	!	!		X$		!
						Restored wetlands	0.2%	1,400	X		!	X$	#	x#	#		X$	X#			!	!	!$		!	!	!	X!	X$	X$!	!
High Phosphorus (TP) Concentrations	**60% reduction** in multi-year FWMC (from 0.38 to 0.15 mg/L)	60	**10% reduction**	Upland/ field surface runoff	**4%**	Strategies to reduce TSS from fields (see above)	see above		see above																						
						Nutrient (including manure) management/reduced application	20.0%	140,000	X	X	!	X$	#	#	#	X	X$			#	!	!$	!$	!		X!	!		X$		!
						Treatment wetlands *	1.0%	7,100	X		!	X$	#	#	#		X$	#			!	!	!	!	!	!	!		X$		!
						Restored wetlands	0.2%	1,400	X		!	X$	#	x#	#		X$	X#			!	!	!$		!	!	!	X!	X$	X$!	!
				Bank/bluff erosion	**2%**	Strategies to reduce TSS from banks/bluffs (see above)	see above		see above																						
				Tile drainage water	**4%**	Strategies to reduce TN from tile drainage water (see above)	see above		see above																						
High Bacteria/ E. coli Concentrations	**50% reduction** in high monthly geomean (from 251 to 126 mpn/100 mL)	19	**27% reduction**	Manured field/surface runoff	**17%**	Strategies to reduce field TSS (applied to manured fields, see above)	see above		see above																						
						Improved field manure (nutrient) management	7.8%	55,000	X		!		#	#	#	X	X$	#		X#	!	!$	!$	!		X!	!		X$		!
						Adhere/increase application setbacks	25% of manured fields		X		#			X#	#				X	X#	X	X			#	X					
						Improve feedlot runoff control	Eliminate or treat all runoff		X		!			#	#		X$			X#	#	!							X$		
						Rotational grazing and livestock exclusion	25% of grazed riparian areas		X		!		#	#	#		X$			$#		!							X$		
				Improperly treated human sewage	**10%**	Replace failing septic (SSTS) systems	to achieve <10% failing		X	X	!	X	#	X#	#		X		$		!	!	!	!			!				
						Maintain septic (SSTS) systems	to achieve >60% maintained		X	X			#	#	#				!												
						Reduce straight pipe (untreated) residential discharges	reduce by >75%		X	X	!	X!	#	#	#		#	X	X$		!#	!	!	!			!				
						Reduce WWTP untreated (emergency) releases	minimize					X										!					!				!

Pollutant/ Stressor	Goal	Years to Goal	10-year Target	Priority Source(s)	10-year target for source	**Restoration and Protection Strategies** to meet 10-year target see notes on page 30	Scale of Adoption: % of watershed to newly adopt strategy*	Scale of Adoption: New adoption (in treated acres*)	Responsibility & Role (see key on page 30) — Local: Farmers	Local: Residents	Local: GBERBA	Local: Cities	Local: Conservation Groups	Local: Lake Associations	Local: Citizen Network	Local: Crop Consultants	County: SWCD	County: Drainage Authority	County: P&Z or Env. Service	County: Feedlot staff	County: Boards & Supervisors	State: PCA	State: BWSR	State: MDA	State: DNR	State: MDH	State: Legislators	State: DOT	Federal: NRCS	Federal: Fish & Wildlife	Federal: Legislators
Poor Habitat	**Improve Poor Habitat** (no numeric goal yet)	50	**Improve/ Maintain** (no numeric goal)	Degraded riparian	**improve riparian zone**	50' buffer on protected of waterways	>75% buffered		X	X		X	#	#	#		#X	#	X		#	#	#	#	X				#	#	
						One rod ditch buffers (voluntarily and via reassessment)	>50% buffered		X		#	X	#	#	#		#	X	#		!	#	#	#	#				#		
						Lake shoreland buffers	>50% buffered		X	X		X	#	X#	#		#X	#	X		#	#	#	#	X				#	#	
						Increase conservation cover: in/near water bodies, to create corridors			X	X	!	X	X$#	#	#		X$	X					!	!	!		!		X$	!$	!
						Improve/increase natural habitat in riparian, control invasive species			#	#	!	X	X#	X#	#		#$		#		#	#	!	#	X$!		!		X$	X$	!
						Accurately size bridges and culverts to improve stream stability																									
				Altered hydrology		Strategies to address altered hydrology (see bove)	see above		see above																						
				High TSS		Strategies to reduce TSS (see above)	see above		see above																						
Non-point Source City/ Residential Contributions	Assume need same % reductions per area as watershed wide goals	50	**5%**	Storm water runoff, Impervious surfaces, Construction runoff, etc..	**5%**	Improve city stormwater catchment/management				#	!	X$	#	#	#		$	#	X!		#!	!	!			!	!	!			
						Mitigate effects of increased urbanization using appropriate stormwater BMPs				#		X$	#	#	#		$	#	X!		#!	!	!			!	!	!			!
						Increase open space and naturally vegetated areas in cities				X		X$	X#	X#	#		$		X!		#!										
						Resident and city nutrient management (and education program)				X	$!	X$	X#	X#	#		#$		X!		#!	!	!			!					
						Resident-scale water management: increase infiltration & ET, rain gardens/barrels, decrease watering				X	!	X$	#	X#	#		$		X!		#!	!	!								
						Improve/enforce city stormwater runoff standards				#		X		#					X!		X!	!					!				
						Improve/enforce construction site erosion control plans				#		X		#					X!		X!	!					!				
High Phosphorus Concentrations in Lake Watersheds	**60% reduction** in average seasonal TP Concentration (on average for all lakes)	40/60	**10/15%** (depending on lake-watershed ratio: 10% for lakes with large ratio and 15% for lakes with small ratio)	Field surface runoff, malfunctioning septic systems, and tile drainage	**10/15%**	Strategies to reduce TP from fields and tile drainage water sources (see above)			see above																						
						Strategies to reduce non-point city/residential contributions (see above)			see above																						
						Landowner education: nutrients, shoreline, septic systems, etc.			#	#	!	X$	#	X#$	#		$		X!		!	!	!	!	!	!	!		X		
						Restore/maintain lake shore/buffer and inlake native vegetation, control invasive species			X	X	!	X$	X#	X#$	#		$		X!		!	!	!	!	!	!	!		X		
						Septic (SSTS) system maintenance/replacement			X	X	!	X	#	X#	#		X		$		!	!	!	!			!				
						Increase structural set-backs from lake			#	#				#					X		X!				#						
						Enforce construction site erosion control plans													X		X!	!			X						
						Enforce/establish shoreland rules/buffer ordinance			#	#				#	#				X		X!				X!		X!				
						Reduce/eliminate runoff from livestock "open lots" adjacent lake			X	#	!		#	#	#		$		!	X!	!	!	!	!					X$		
						Improve feedlot runoff controls			X		!						$			X!	!	!	!								
						Internal treatments (fish, chemical, dredging) where external phosphorus source have been controlled			#	#		#$	#	#$	#		#		#		#	!	!		X!		!				
						Co-develop individualized plans for lakes with strong and invested local working group support (as requested). Plans will be based on strategies presented above.			#	#	#	X#	X#	X#			X#		X		#!	X!	!		X						
General Strategies for All Pollutants/ Stressors	**Comprehensively address social infrastructure** (education, funding, trust, consumption) that are necessary to increase BMP adoption. **Ensure point source compliance** is achieved through regulation. Work to **effectively target BMPs**.	n/a	meet 10-year targets (see above)	Current limitations in BMP adoption due to financial security/risk avoidance, trust, and other social infrastructure issues.	n/a	Citizen education and relationship building, developed collaboratively between agencies			#	#	!#	#$	X#	X#	X#	#	#$	#	#	#	#!	!#	!#	!#	!#	!#	!#	#	X$#	#	#
						Elected county official education					X						X	X	X	X	#	X	X	X	X	X		X	X		
						More LGU to landowner communications (one-on-one) and more state agency to LGU communications			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
						Increased support of water quality friendly agricultural products and small family farms				X	X		X	X	X		X				X	X!	X!	X!	X		X!		X!		X!
						Additional project, staff, and technical assistance dollars and programs					#	#	#				#				#X	X	X	X	X		X$		X		X$
						Simplified funding processes																X	X	X	X	X	X		X	X	X
						Increased voluntary adoption of un-funded projects (e.g. nutrient management)			X	X		X	X	X																	
						Establish more farm and ditch demonstration sites including biologically-integrated farms and new technologies			X		!				X		X$	X$			X!#	!	!		!		#		X$		#
						Systematic ditch system reassessments												X			!						#!				
						Minimize ditch clean-outs to maintain ditch vegetation and channel stability			X				#	#	#		#	X!			!#	!#	!#	!#	!#				#		
						Improve construction/NPDES permits based on TMDLs						X							X			X									
						NPDES/SDS and MS4 permit compliance						X							X	X	!	X									
						Field-scale data/modeling to target conservation			#	#	!	X	#	#	#		X	#	X	#	!	!	!	X	!	!			X		
						Co-develop individualized reach or subwatershed plans and strategy targeting maps for locations with strong and invested local working group support.			#	#	#	X#	X#	#	#		X#	X#	X		#!	X!	!		X				X		
Protection Considerations for All Pollutants/ Stressors	Protect water bodies and naturalized areas from degradation. Protect businesses, agricultural producers, and cities from debilitating economic impacts. Protect human health.	n/a	prevent degradation	Agricultural and city development, particularly effects to hydrology. Changes in hydrology due to future climate changes.	n/a	Protect watershed bodies by adopting strategies (as specified above) to buffer future human and climate changes. Protection bodies include: those meeting water quality standards, sentinel lakes			X#	X#	X#	X#	X#	X#	X#	X#	X#	X#	X#	X#	X#	X#	X#	X#	X#	X#	X#	X#	X#	X#	X#
						Mitigate changes to hydrology from new/upgraded drainage (agricultural and city) systems on/near-site			X	X		X			#			X	X		!	!	!		!		!#				!#
						Create programs/insurance sufficient to secure economics for those working to improve water quality																					X				X
						Zero wetland, grassland, and forest loss (net, but minimize disturbance as much as possible)			X	X		X	#	#	#		#	X	X		#!	!	!	!	!				X		
						Protect high quality habitat including (but not limited to):			X	X	!	X	#	#	#	#	X$	X	X	X	!	!	!	!	!		!	X	X	X	!
						▪ Designated Wildlife Management Areas & Wildlife Lakes, Natural Environmental Lakes																									
						▪ Forested riparian tracts adjacent to lakes and especially undeveloped islands																									
						▪ Natural habitats along the Le Sueur, especially larger and/or more contiguous tracts																									
						▪ Lily Lake (a wild rice lake), Waseca County 81-67P (east side of Elysian)																									
						▪ Wetland/upland habitat complexes (including St. Olaf, Fositen, Lonergan Lakes, Reese Lake)																									

Key for Responsibility & Role

X = Identify and/or implement projects
$ = Direct financial and/or technical project support
! = Oversight, approval, support, and/or funding to local groups
= Conversations and relationship building

***** The project footprint is only a fraction of the treated acres, which should be considered when comparing adoption rates. One example: restored wetland (no *) adoption rate indicates the target number of acres be restored to wetlands. Alternately, treatment wetlands (w/ *) is intended to treat the water from many more acres than the strategy footprint. So the actual acres converted to treatment wetlands would be a fraction (e.g. 1/20th or 1/100th) of the treated acres.

† The strategies in this table do not supersede, replace, reduce, or add to any NPDES or MS4 permit requirements. Permitted entities should continue working with their permit writer to ensure compliance with TMDLs or other mandates.

Ag BMP strategy NRCS project code and Additional Notes

See the NRCS design guidance and/or the Ag BMP handbook for additional information

Ag BMP	NRCS code(s)	Additional Notes
Conservation cover	327, 643	native vegetation best including grasses, trees, shrubs
Conservation tillage	329, 345, 346	no till or strip till with very high residue
Cover crops	340	locally recommended to use in conjunction with cons tillage
Crop rotation	328	consider in conjunction with cover crops and cons tillage
Feedlot runoff control	635, 362	
Field buffers, borders, filter strips	393, 386, 332	edge-of-field or within field
Grassed waterways	412	
In/near ditch retention and treatment	410, 587	Includes any practice where the ditch itself is incorporated in to practice: 2-state ditch, side inlet control, weirs and berms, etc.
Livestock exclusion	382, 472, 614	exclusion from water bodies, can help to create watering station
Manure application setbacks	590	one specific component of nutrient management
Nutrient (including manure) management	590	considers amount, source, form, timing, etc..
Ravine (grade) stabilization	410	first address hydrology before costly stabilization
Restored wetlands	657, 643, 644	restoring wetland (where one historically was located)
Rotational grazing	528	managing for improved vegetation improves water quality
Saturated buffers	739	
Streambank stabilization	580	using bioengineering techniques as much as possible
Tile system design; controlled drainage	554	managing for less total runoff; includes alternative tile intakes
Treatment wetlands	656, 658	specifically designed to treat tile drainage and/or surface runoff
Water and sediment basins, terraces	638, 600	managing for extended retention and settling
Woodchip bioreactors	747	

6. Appendix

6.1 Agricultural BMP Summary Table

Conservation Practice			Relative Effectiveness, Summarized Effectiveness Data, and Level of Study - by Pollutant/Stressor							
Practice "group"		Individual Practices (Ag BMP Handbook page#)	Sediment (from upland/field)	Phosphorus (Total, dissolved, or particulate)	Nitrogen (Total, nitrate, or dissolved)	Pesticides (one or more)	Bacteria (fecal and/or e. coli)	Hydrology	Habitat	Sediment (from bank, bluff, channel or ravine)
Restore to natural/ minimal management		Conservation Cover (22) land out of production, into vegetation	*	*	10mg/L in streams with 3% of watershed in practice **					
Restore to natural/ minimal management		Restored Wetland (151) (previously drained; typically larger)	>75% reduction *	0-50% TP reduction *	68- >85% TN reduction *					
Improve soil health and/or vegetation	General (can do anywhere)	Cover Crops (36)	32-92% reduction	54-94% TP reduction 7-63% dP reduction	13-64% TN reduction 66% TN reduction**	40% reduction		11% reduction in volume of tile drainage		
Improve soil health and/or vegetation	General (can do anywhere)	Conservation Tillage (94) (no-till or high residue)	90% reduction 6-99% reduction **	57% dP reduction 59-91% TP reduction **	-3-91% TN reduction **			56%-99% reduction in surface runoff		
Improve soil health and/or vegetation	General (can do anywhere)	Nutrient Management (48)	15-65% reduction after adding manure**	50% dP reduction 14-91% TP reduction**	10-40% TN reduction**			2-62% reduction in runoff volume after adding manure		
Improve soil health and/or vegetation	General (can do anywhere)	Crop Rotation (26) including perennial or small grains	32-92% reduction	53-67% TP reduction	59-62% TN reduction 66-68% TN reduction *					
Improve soil health and/or vegetation	General (can do anywhere)	Pest Management (60)				17-43% reduction 40-50% (5 years) 70-80% (10 years)*				
Improve soil health and/or vegetation	Site-specific	Contour Buffer Strips (28) applies only to steep fields	83-91% reduction 30-94% reduction*	49-80% TP reduction 20-50% dP reduction	27-50% TN reduction 18-49% dN reduction	53-77% reduction*	43-74% reduction			
Improve soil health and/or vegetation	Site-specific	Grassed Waterway (84) for concentrated surface flows/gullies	94-98% reduction 77-97% reduction **			70-96% reduction **		2-20% reduction in surface runoff (modeled)		
Improve soil health and/or vegetation	Site-specific	Contour Stripcropping (72) 50% or more of field in grass, etc..	43-95% reduction	70-85% TP reduction 8-93% TP reduction	20-55% TN reduction					
Improve soil health and/or vegetation	Site-specific	Terrace (113) applies only to steep fields	80-95% reduction	70-85% TP reduction	20-55% TN reduction					
Improve soil health and/or vegetation	Site-specific	Contour Farming (33) applies only to steep fields	28-67% reduction	10-62% TP reduction	25-68% TN reduction					
Improve water manage-ment (retention and filtration)	Tile drainage /subsurface water	Alternative Tile Intakes (67) replacing open intakes	70-100% reduction*	*						
Improve water manage-ment (retention and filtration)	Tile drainage /subsurface water	Tile System Design (63) shallower and wider pattern			40-47% NO_3 reduction					
Improve water manage-ment (retention and filtration)	Tile drainage /subsurface water	Saturated Buffers (not in handbook) intercepting tile drainage water								
Improve water manage-ment (retention and filtration)	Tile drainage /subsurface water	Controlled Drainage (75)		50% TP reduction 63% dP reduction *	20-61% NO_3 reduction *			15-50% reduction in volume of tile drainage		
Improve water manage-ment (retention and filtration)	Tile drainage /subsurface water	Woodchip Bioreactor (156) (for tile drainage water)		*	30-50% NO_3 reduction *	*	*			
Improve water manage-ment (retention and filtration)	Surface water	Treatment Wetland (146) (constructed; typically smaller)	75% reduction in urban settings *	59% TP reduction * 49-56% dP reduction 71-74% TP	40-43% TN reduction 64% TN reduction					
Improve water manage-ment (retention and filtration)	Surface water	Filter Strips, Field Borders (125)	76-91% reduction 0-99% reduction **	38-96% TP reduction 50% dP reduction 2-93% TP	27% TN reduction 1-93% NO_3 reduction **	45-78% reduction *	*			
Improve water manage-ment (retention and filtration)	Surface water	Sediment Basin (134)	60-90% reduction 77% reduction	34-73% TP reduction 72% TP reduction	30% TN reduction 82% NO_3 reduction		70% reduction			
Improve water manage-ment (retention and filtration)	Surface water	Side Inlet Control to Ditch (137) for grade stabilization and retention								
Improve water manage-ment (retention and filtration)	Surface water	Extended Retention (80) created by culvert/road design						11-41% reduction in 10-yr peak flow for drainage area		
Improve water manage-ment (retention and filtration)	Surface water	Water & Sediment Basin (143)	64 (modeled) - 99% reduction	74% organic P 80% sediment-bound P (modeled)						
Improve riparian areas		Riparian and Channel Veg (99) intercepting surface runoff	53-99.7% reduction 55-95% reduction	41-93% TP reduction 63% pP reduction	58-92% TN reduction 37-57% TN reduction					
Improve riparian areas		Streambank Stabilization (109) using bioengineering techniques								
Improve riparian areas		Two Stage Ditch (115) replacing trapezoidal ditch			5-15% TN reduction*					*
Improve riparian areas		Grade Stabilization (40) of headcut in ravine or small channel								75-90% reduction
Improve livestock and/or manure management		Rotational Grazing (103) replacing row crops/continuous graze	49% reduction compared to row crop	75% reduction compared to row crop	62% reduction compared to row crop		consistently lower than continuous graze			
Improve livestock and/or manure management		Livestock Exclusion (45) applies only to livestock operations		75% TP reduction	62% TN reduction 32% NO_3 reduction					49% reduction 82-84% reduction
Improve livestock and/or manure management		Waste Storage Facility (91) improved from leaky structure		25-90% TP reduction	29-80% TN reduction*					
Improve livestock and/or manure management		Feedlot Runoff Control (121) improvements to system with runoff	79% reduction 35-95% reduction *	83% TP reduction * 30-85% TP reduction	84% TN reduction 10-45% TN reduction *		Up to 99% removal *	67% reduction in surface runoff		

Notes: Numeric effectiveness and level of study from the MN Ag BMP Handbook (Miller et al., 2012). Relative effectiveness (shades) estimated by local conservation professionals. Refer to the handbook for additional details and before selecting a BMP to ensure its applicability, siting and design criteria. Rev date: 4/29/14 JB

Relative Effectiveness
- very effective BMP
- somewhat effective BMP
- minimally effective BMP
- not effective BMP

Level of Study in Upper Midwest
- ** well studied
- * some study

6.2 Computer Model Summaries

Model(s) & Report	Summary & Notes	Scenario	Modeled Landscape/BMP(s)	Parameter Reduction: Sediment	Parameter Reduction: Phosphorus	Parameter Reduction: Nitrate/N	Cost
Nitrogen BMP Spreadsheet Minnesota Watershed Nitrogen Reduction Planning Tool (Lazarus et al., 2013)	The BMPs outlined here were developed using the nitrogen reduction spreadsheet with inputs specifically for the Le Sueur River watershed. This represents just one of endless scenarios than can be analyzed with this tool. Total cumulative nitrogen reduction for all BMPs applied is 25%. Reductions for individual BMPs are listed under the Parameter Reductions columns. Parameter Reductions do not add up to the cumulative reduction because some practices are mutually exclusive and therefore, fewer acres are available for practices.	Individual or All (see notes)	30% of area (80% of corn fields) receives target N application rate (30% less)			11.8%	**$-3/lb N**
			20% of area (80% of fall appliers) switches to spring N application			12.7%	**$-1/lb**
			5% of area (20% of fall appliers) switches to 70% side-dress, 30% preplant			3.5%	$2/lb N
			10% of area (15% of corn and beans) plants rye cover crop (50% success)			3.4%	$15/lb N
			2.5% of area is in riparian buffer (50' on all streams in watershed)			2.5%	$13/lb N
			2% of area (15% of estimated drained wetlands) restored to wetlands			1.6%	$1/lb N
			2% of area (80% of farmed marginal land) converted to perennial grass			1.7%	$11/lb N
			1.5% of area (15% of suitable areas) has bioreactors			0.3%	$9/lb N
			1.5% of area (20% of suitable areas) has controlled drainage			0.7%	$2/lb N
SPARROW The Minnesota Nutrient Reduction Strategy (draft) (MPCA, 2013i)	Statewide nutrient reduction goals and strategies are developed for the three major drainage basins in Minnesota. For the Mississippi River basin, the milestones (interim targets) between 2014 and 2025 are 20% reduction in N and 8% reduction in P.	2025 Milestone	43% of total area (80% of suitable area) uses target N fertilizer rates 6% of total area (90% of suitable area) uses P test and soil banding 1% of total area (10% of suitable area) in cover crops 1% of total area (25% of suitable area) in riparian buffers 25% of total area (91% of suitable area) in conservation tillage 4% of total area (18% of suitable area) uses wetlands or controlled drainage		8%	20%	
HSPF Minnesota River Basin Turbidity Scenario Report (Tetra Tech, 2009)	5 scenarios (BMP suites) evaluated for effect on TSS and TP in MN River tributaries and mainstem. Scenarios 1, 2 were minimally effective. HSPF capable of modeling stream dynamics. Load reductions are either reported specifically for the Le Sueur River Watershed where possible or generally for the MN River Basin, depending on how the report summarized those numbers. Analysis on 2001-2005 data.	3	20% land in pasture (perennial veg), targeting steepest land 75% of >3% slope land in cons. tillage (30% residue), cover crop 50% of surface inlets eliminated Comprehensive nutrient management Drop structures installed on eroding ravines Effluent max P of 0.3mg/L for mechanical facilities For MS4 cities, install ponds to hold and treat 1" of runoff	~20% (Le Sueur watershed)	17% (MN basin)		
		4	All BMPs in Scenario 3 with these additions: Target (20% land in) pasture to knickpoint regions as well Increase residue (on 75% of >3% slope land) to 37.5% Increase eliminated surface inlets to 100% Controlled drainage on land with <1% slope Water basins to store 1" of runoff Minor bank/bluff improvements Eliminate baseflow sediment load	47% (Le Sueur watershed)	26% (MN basin)		
		5	All BMPs in Scenario 4 with these additions: Improved management of the pasture land (CRP) Very major bluff/bank improvements Urban (outside MS4s) source reductions of 50-85%	87% (MN basin)	49% (MN basin)		

Model(s) & Report	Summary & Notes	Land uses:	Scenario	Normal til	Cons til	1/2 P fert	Pasture	Grass	Forest	Wetland	Water	Urban	Sediment	Phosphorus	Nitrate/N	Cost
SWAT, InVEST, Sediment Rating Curve Regression, and Optimization Lake Pepin Watershed Full Cost Accounting (Dalzell et al., 2012)	Models 6 BMPs in the 7-mile Creek watershed either: **1**) placed by rule of thumb recommendations (not optimal) or **2**) to maximize TSS reduction for dollars spent (optimal). Completed economic analyses including: **A**) current market value only (using 2011 $) and **B**) integrated, which adds a valuation of ecosystem services (relatively modest value). Does not allow multiple BMPs on same pixel of land. Scenarios are described by percentages of land in each land use. Analysis of 2002-2008 data.	Baseline		83%	0%	0%	2%	0%	4%	5%	1%	5%	0%	0%		0%
		2A	A	3%	14%	64%	3%	1%	5%	5%	1%	5%	4%	-1%		**-4%**
			B	35%	1%	38%	10%	1%	4%	5%	1%	5%	25%	22%		4%
			C	8%	0%	35%	32%	10%	4%	5%	1%	5%	50%	46%		21%
			D	2%	0%	10%	43%	29%	4%	5%	1%	5%	76%	69%		51%
		2B	a	30%	1%	44%	2%	0%	11%	5%	1%	5%	15%	19%		-8%
			b	26%	0%	41%	13%	1%	7%	5%	1%	5%	25%	28%		-7%
			c	13%	0%	29%	38%	2%	7%	5%	1%	5%	50%	48%		0%
			d	3%	0%	8%	68%	3%	6%	5%	1%	5%	76%	70%		19%
		1A	F	25m grass buffers around waterways									3%	3%		4%
			G	250m grass buffers around waterways									15%	15%		28%
			H	Converting highly erodible lands to grasslands									15%	17%		10%

Model(s) & Report	Summary & Notes	Scenario	Modeled Landscape/BMP(s)	Sediment	Phosphorus	Nitrate/N	Cost
SWAT Modeling of Sediment, Nutrients and Pesticides in the Le Sueur River Watershed (Folle, 2010)	Evaluated contributions from uplands only (SWAT does not model stream, bluff, ravine, etc.. dynamics) in the Beauford Ditch subwatershed. The number in parentheses is the direct reported loss from reduction from upland only. Reductions are extrapolated (here) to all sources with these assumptions: TSS -21% upland, TP-80% upland, Nitrate -90% upland. Analysis on 1994-2006 data.	Individual BMPs only	Conservation tillage (30% residue) on all corn going to bean	3% (13%)			
			Conservation tillage (30% residue) on field >2% slope	3% (13%)			
			Conservation tillage (30% residue) on 50% of corn to bean	2% (9%)	12% (15%)	0%	
			No till on 50% of corn going to bean	7% (31%)	20% (25%)	1.5% (1.7%)	
			Vegetated filter strips on fields >2% slope	12% (56%)	52% (65%)	2.5% (2.8%)	
			Vegetated filter strips on corn/bean in "critical areas"	4% (20%)			
			Cover crop (rye) after bean harvest	7% (32%)	22% (28%)	17% (19%)	
			Agronomic rate application of P (34% less applied)		22% (28%)		
			20% less N applied (fall apply manure & anhydrous ammonia)			20% (22%)	
			Less N applied (spring apply urea)			6% (7%)	

6.3 Available GIS Targeting Tools/Data Layers

This information was compiled as a quick resource for GIS users. Sources are not technically referenced but are associated with the provided link.

Tool	Description	Example Uses	Notes for GIS Use	Link to Data/Info
Hydrological Simulation Program – FORTRAN (HSPF)	Simulation of watershed hydrology and water quality. Incorporates point and non-point sources including pervious land surfaces, runoff and constituent loading from impervious land surfaces, and flow of water and transport/ transformation of chemical constituents in stream reaches. The model is typically calibrated with monitoring data to ensure accurate results.	Since the model produces data on a subwatershed scale, the model output can be particularly useful for identifying "priority" subwatersheds. The modeled pollutant or concentrations or total loads include TSS, TP, and TN. Point and non-point contributions can be extracted seperately. Can be used to analyze different BMP "scenarios".	PCA models many major watersheds with HSPF. If completed, model data can be obtained from PCA and imported into GIS.	http://water.usgs.gov/software/HSPF/
National Hydrography Dataset (NHD) & Watershed Boundary Dataset (WBD)	The NHD is a vector GIS layer that contains features such as lakes, ponds, streams, rivers, canals, dams and stream gages, including flow paths. The WBD is a companion vector GIS layer that contains watershed delineations.	General mapping and analysis of surface-water systems. A specific application of the data set is to identify buffers around riparian areas.	GIS layers are available on the USGS website.	http://nhd.usgs.gov/
Impaired Waterbodies	Data indicates which stream reaches, lakes, and wetlands have been identified as impaired, or not meeting water quality standards. Attribute table includes information on the impairment parameters.	Examples of region/subwatershed priortization includes: the number of impairments, specific impairment parameter, % of stream miles/lakes that are impaired, immediate subwatersheds of impaired rivers/lakes, identifying reaches with specific impairment parameters, etc. Field-scale targeting examples include: buffering impaired waters.	GIS layers are available on the PCA website.	http://www.pca.state.mn.us/index.php/data/spatial-data.html?show_descr=1
1855 Land Survey Data	Data originally created by land surveyors in the mid-to-late 1800s. Surveys were conducted in one-mile grid and indicatecd the land cover at the time of the survey. This data has been georeferenced and is availble for most of the state. This information has been digitized by PCA staff for the GRBERB.	This information could be used to prioritize areas based on changes in the landscape. This information is also helpful to understand landscape limitations (e.g. former lake beds may not be drain well).	Image data is available from MN Geo. Digitized rivers, lakes, and wetlands (in the GBERB only) are available from PCA staff.	http://www.mngeo.state.mn.us/glo/
Historical Wetlands (PCA Analysis)	Data was created for the GBERB by PCA staff. Created using a combination of techniques including using the 1855 digitized features and a terrain and soils-based analysis.	This data can be used to identify locations to target wetland restorations. Areas with high % of lost wetlands may be prioritized.	Data available from PCA staff (in the GBERB only).	
Restorable Depressional Wetland Inventory	A GIS layer representing drained, potentially restorable wetlands in agricultural landscapes. Created primarily through photo-interpretation of 1:40,000 scale color infrared photographs acquired in April and May, 1991 and 1992.	Identify restorable wetland areas with an emphasis on: wildlife habitat, surface and ground water quality, reducing flood damage risk. To see a comprehensive map of restorable wetlands, must display this dataset in conjunction with the USGS National Wetlands Inventory (NWI) polygons that have a 'd' modifier in their NWI classification code	GIS layer is available on the DNR Data Deli website also available from Ducks Unlimited.	http://deli.dnr.state.mn.us/metadata.html?id=L390002730201 ; http://prairie.ducks.org/index.cfm?&page=minnesota/restorablewetlands/home.htm#downfile
"Altered Hydrology" (PCA Analysis)	GIS layers (results of GIS analysis) of hydrology-influencing parameters indicating the amount of change (since European settlement) including: % tiled, % wetland loss, % stream channelized, % increase in waterway length, % not perrenial vegetation, % impervious. Analysis done at the same subwatershed scale as the HSPF modeling was completed to facilitate subwatershed prioritization. Analysis was completed using available GIS data layers.	These 6 layers could be used individually or in combination (using raster calcuator) to prioritize subwatersheds to target conservation practices intended to mitigate altered hydrology.	GIS layers (in the Le Sueur Watershed only) are available from PCA staff.	
Altered Watercourse Dataset (Channelized Streams)	Statewide data layer that identifies portions of the National Hydrography Dataset (NHD) that have been visually determined to be hydrologically modified (i.e., ditches, channelized streams and impoundments).	Identifies streams with highly modified stream channels for conservation prioritization. Subwatersheds with high levels of channelized streams may be prioritized for specific conservation practices.	GIS layers are available on the MN Geo website.	http://www.mngeo.state.mn.us/ProjectServices/awat/
Tile Inventory	Data exists in a very limited extent at the County level. The data layer can be created by digitizing visible tile lines from imagery.	Knowing the location, extent, and spacing of tile can help define priority areas or target fields to implement practices that address altered hydrology.	Contact you County to see if any data exists.	
Tile Drainage (PCA Analysis)	Data created as an estimate of whether a pixel is tiled or not. Assumes tiled if: row crop, <3% slope, poorly drained soil type	Can be useful for prioritizing highly drained areas to implement BMPs that address altered hydrology.	Data can be obtained from PCA staff	
Light Detection and Ranging (LiDAR)	Elevation data in a digital elevation model (DEM) GIS layer. Created from remote sensing technology that uses laser light to detect and measure surface features on the earth.	General mapping and analysis of elevation/terrain. These data have been used for: erosion analysis, water storage and flow analysis, siting and design of BMPs, wetland mapping, and flood control mapping. A specific application of the data set is to delineate small catchments.	The layers are available on the MN Geospatial Information website for most counties.	http://www.mngeo.state.mn.us/chouse/elevation/lidar.html
Stream Power Index (SPI)	SPI, a caluclation based on a LiDAR file, describes potential flow erosion at the given point of the topographic surface. As catchment area and slope gradient increase, the amount of water contributed by upslope areas and the velocity of water flow increase. Varying SPI analysese have been done with different resulting qualitites depending on the amount of hydrologic conditioning that has been done.	Useful for identifying areas of concentrated flows which can be helpful for targeting practices such as grassed waterways or WASCOBs. Again, the usefulness may depend on the level of hydrologic conditoning that has been done.	This layer has been created by PCA staff with little hydroconditioning for the GBERB and can be obtained from PCA staff.	http://iflorinsky.narod.ru/si.htm
Compound Topographic Index (CTI)	CTI, a calculation basedon a LiDAR file, is a steady state wetness index. The CTI is a function of both the slope and the upstream contributing area per unit width orthigonal to the flow direction. CTI was desigined for hillslope catenas. Accumulation numbers in flat areas will be very large and CTI will not be a relevant variable.	Identifies likely locations of soil saturation which can be useful for targeting certain practices.	Can be downloaded from ESRI	http://arcscripts.esri.com/details.asp?dbid=11863
NRCS Engineering Toolbox	The free, python based toolsets for ArcGIS 9.3 and 10.0 allow for user friendly use of Lidar Data for field office applications, Hydro-Conditioning, Watershed Delineation, conservation planning and more.	Many uses including siting and preliminary design of BMPs.	Toolbox and training materials available on the MnGeo site.	http://www.mngeo.state.mn.us/chouse/elevation/lidar.html
RUSLE2	RUSLE2 estimates rates of rill and interrill soil erosion caused by rainfall and its associated overland flow. Several data layers and mathematical calculations are used to estimate this erosion.	Estimating erosion to target field sediment controllign practices.		http://www.ars.usda.gov/Research/docs.htm?docid=6016
Crop Land - National Agricultural Statistics Service (NASS)	Data on the crop type for a specific year. Multiple years data sets availble.	Identify crop types, including perrennial or annual crops and look at crop rotations/changes from year to year. A specific example of a use is to identify locations with a short season crop to target cover crops practice.	Data available for download from the USDA or use the online mapping tool.	http://www.nass.usda.gov/research/Cropland/SARS1a.htm
National Land Cover Database (NLCD) from the MRLC	Data on land use and characteristics of the land surface such as thematic class (urban, agriculture, and forest), percent impervious surface, and percent tree canopy cover.	Identify land uses and target practices based on land use. One example may be to target a residental rain garden/barrel program to an areas with high levels of impervious surfaces.	Data available for download from the MRLC website	http://www.mrlc.gov/
CRP land (2008)	Data on which areas were enrolled in th USDA Conservation Reserve Program. This data is no longer available but may exist at the county level.	Potential uses include targeting areas to create habitat coridors or targeting areas coming out of CRP to implement specific BMPs.		http://www.fsa.usda.gov/FSA/webapp?area=home&subject=copr&topic=crp
Soils Data (SSURGO)	Data indicates soil type and properties.	Soil types can be used to determine the acceptableness of a practice based on properties such as permeability or erosvity.	Data can be downloaded or online viewers are available on the NRCS website.	http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627

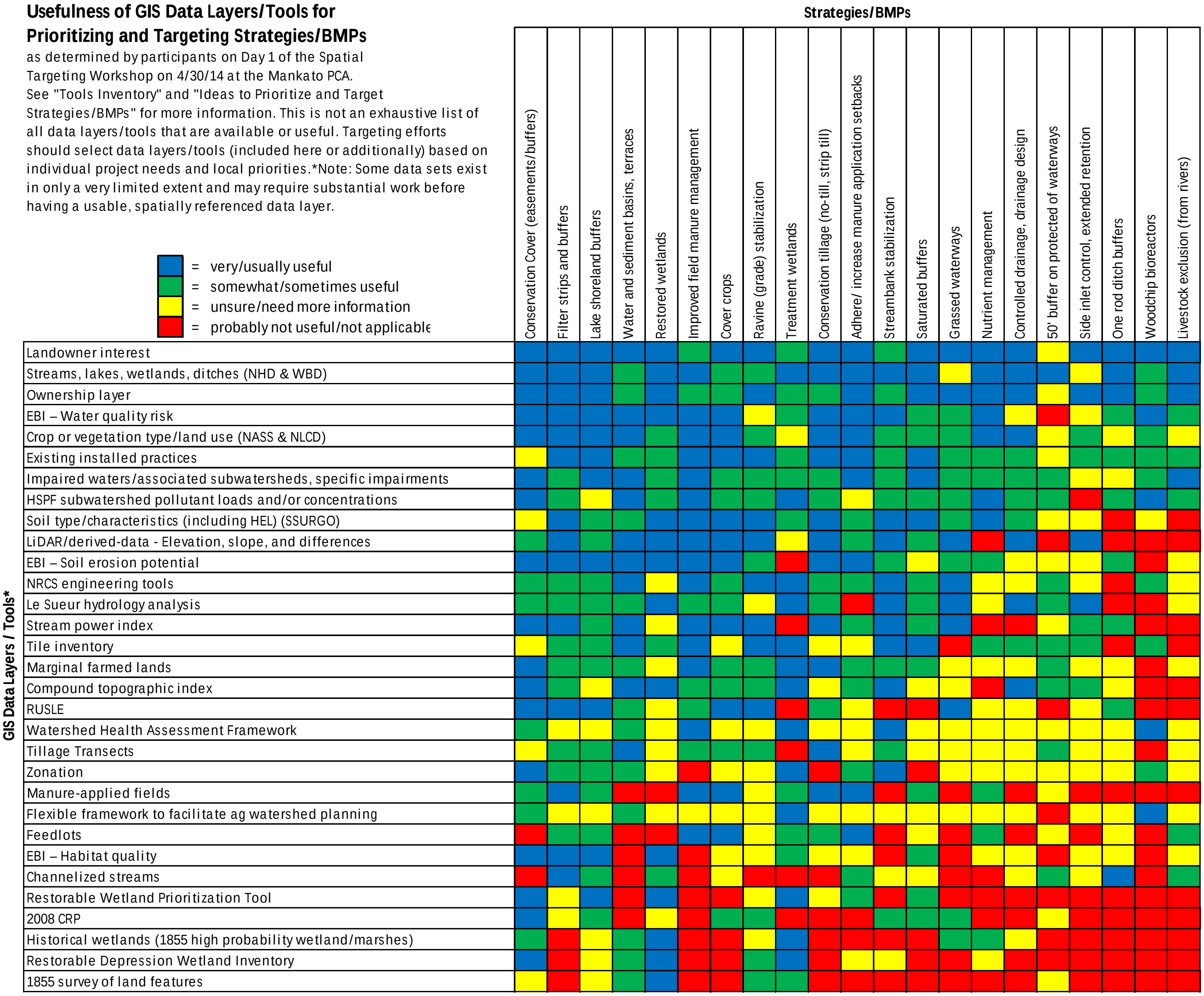
Tool	Description	Example Uses	Notes for GIS Use	Link to Data/Info
Manure-applied Fields	Data on which fields received manure (and possible the rate in which manure is applied). This data exists in a spatial format in a very limited extent based on the County Feedlot record keeping. This information could be created from manure management plans and/or annual reports. Martin County has created this layer.	Identifying areas of heavy manure usage. This can be helpful when prioritizing or targeting areas to address E. coli.	Contact County feedlot staff to inquire	
Feedlot Locations	Data indicates the location of existing feedlots. Some data in this data layer is not accurate and feedlot locations could be mapped at the owner's address or in the center of the quarter quarter.	May be helpful prioritizing areas to implement strategies that address E. coli or nutrients.	Data available on PCA website	ftp://files.pca.state.mn.us/pub/spatialdata/ see "mpca_feedlots_ac.zip"
Marginal (Farmed) Lands	Data exists in a limied extent and perhaps not at all in the GBERB. This data can be made using other data layers. There are several ways to define marginal (farmed) lands, but criteria usually include either high levels of environmental sensitivity or areas that make little net profit when farmed.	Useful for identify areas that would be most benefical to take out of crop production to place a BMPs that cannot occur on an actively farmed footprint. Commonly used to identify locations targeted for perrenial (biofuel) crops.	Can be created using one of many established definitions or marginal land (see link).	http://kellylab.berkeley.edu/storage/papers/2014-LewisKelly-IJGI.pdf
Tillage Transect Survy	Data regarding the observed tillage or residue cover. Data exists in a very limited extent. MSU WRC will be doing a survey in the Le Sueur River watershed.	Prioritizing areas or targeting specific fields based on the type of tillage used.	Contact Rick Moore at WRC	: http://mrbdc.mnsu.edu/minnesota-tillage-transect-survey-data-center
Land Ownership/ Property Boundaries	Data indicates the owner and property boundary. This data is kept at the county level.	May be helpful for targeting efforts, particularily when a proactive approach is taken (e.g. if areas are targeted for specific practices and land owners are contacted to gauge their interest in a specific practice).	Some data available on the MN Geo webiste. Not all areas may have data in GIS format. Contact specific counties for more details/information.	http://www.mngeo.state.mn.us/chouse/land_own_property.html
Landowner Interest	Data exists in only a very limited extent at this time. The data exists in areas (e.g. County SWCDs) that have tracked this information themselves. Other entities may consider tracking this information.	Having information on interested landowners (including interest in specific projects) increases chances of being funded. An area with many intersted landowners could be high priority.		
Installed Practices	Data exists in a limited extent at this time. Agencies like BWSR, the NRCS, or County SWCDs may be able to provide some information.	Knowing which areas have had multiple practices installed could indicate more interested landowners or help identify areas to anticipate water quality improvements.	Contact listed agencies to inquire if any data is available.	
Watershed Health Assessment Framework (WHAF)	An online spatial program that displays information at the major and subwatershed scaled. Information includes: hydrology, biology, and water quality.	The online program is helpful for quick viewing and could be used to proioritize subwatersheds based on parameters or criteria in the WHAF.	Online only	http://arcgis.dnr.state.mn.us/ewr/whaf/Explore/
Flexible Framework (Tomer et al.)	An outlined methodology uses several data layers and established analyses to identify specific locations to target several different BMPs. A "toolbox" is being created to facilitate the use of this methodology in MN.	Targeting specific BMPs (see link).		http://www.jswconline.org/content/68/5/113A.extract
Ecological Ranking Tool (Environmental Benefit Index - EBI)	Three GIS layers containing: soil erosion risk, water quality risk, and habitat quality. Locations on each layer are assigned a score from 0-100. The sum of all three layer scores (max of 300) is the EBI score; the higher the score, the higher the value in applying restoration or protection.	Any one of the three layers can be used separately or the sum of the layers (EBI) can be used to identify areas that are in line with local priorities. Raster calculator allows a user to make their own sum of the layers to better reflect local values or to target specific conservation practices.	GIS layers are available on the BWSR website.	http://www.bwsr.state.mn.us/ecological_ranking/
Zonation	A values-based framework and software for large-scale spatial conservation prioritization. Allows balancing of alternative land uses, landscape condition and retention, and feature-specific connectivity responses. Produces a hierarchical prioritization of the landscape based on the occurrence levels of features in sites/grid cells. It iteratively removes the least valuable remaining cell, accounting for connectivity and generalized complementarity in the process.	Surveys are created and given to targeted audiences to identity their priorities. These survey priorites are then used by the program. The output of Zonation can be used to identify areas that align with the conservation values of the survey respondents.	Zonation results can be exported to GIS. Paul Radomski (DNR) and colleagues have expertise with Zonation.	http://cbig.it.helsinki.fi/software/zonation/
Restorable Wetland Prioritization Tool	The base layer is a restorable wetlands inventory that predicts restorable wetland locations across the landscape. There are also three decision layers including a stress, viability, and benefits layer. The stress and viability decision layers can be weighted differently depending on the users interest in nitrogen and phosphorus reductions and habitat improvement. Lastly, there is a modifying layer with aerial imagery and other supplemental environmental data.	This tool enables one to prioritize wetland restoration by nitrogen or phosphorus removal and/or by habitat. Additional uses include: locating areas most in need of water quality or habitat improvement; prioritizing areas that already are or are most likely to result in high functioning sustainable wetlands; refining prioritizations with aerial imagery and available environmental data.		https://beaver.nrri.umn.edu/MPCAWLPri/
National Fish Habitat Partnership Data System	Supports coordinated efforts of scientific assessment and data exchange among the partners and stakeholders of the aquatic habitat community. The system provides data access and visualization tools for authoritative NFHP data products and contributed data from partners. Data sets avaialble include: anthropogenic barrier dataset,			http://ecosystems.usgs.gov/fishhabitat/
Indicators of Hydrologic Alteration (IHA)	The Indicators of Hydrologic Alteration (IHA) is a software program that provides useful information for those trying to understand the hydrologic impacts of human activities or trying to develop environmental flow recommendations for water managers. assess how rivers, lakes and groundwater basins have been affected by human activities over time – or to evaluate future water management scenarios.Assess how rivers, lakes and groundwater basins have been affected by human activities over time – or to evaluate future water management scenarios.	The software program assesses 67 ecologically-relevant statistics derived from daily hydrologic data. For instance, the IHA software can calculate the timing and maximum flow of each year's largest flood or lowest flows, then calculates the mean and variance of these values over some period of time. Comparative analysis can then help statistically describe how these patterns have changed for a particular river or lake, due to abrupt impacts such as dam construction or more gradual trends associated with land- and water-use changes.		https://www.conservationgateway.org/ConservationPractices/Freshwater/EnvironmentalFlows/MethodsandTools/IndicatorsofHydrologicAlteration/Pages/indicators-hydrologic-alt.aspx
InVEST	InVEST is a suite of software models used to map and value the goods and services from nature that sustain and fulfill human life. InVEST enables decision makers to assess quantified tradeoffs associated with alternative management choices and to identify areas where investment in natural capital can enhance human development and conservation.	InVEST models can be run independently, or as script tools in the ArcGIS ArcToolBox environment. You will need a mapping software such as QGIS or ArcGIS to view your results. Running InVEST effectively does not require knowledge of Python programming, but it does require basic to intermediate skills in ArcGIS.		http://www.naturalcapitalproject.org/InVEST.html
RIOS	RIOS provides a standardized, science-based approach to watershed management in contexts throughout the world. It combines biophysical, social, and economic data to help users identify the best locations for protection and restoration activities in order to maximize the ecological return on investment, within the bounds of what is			http://www.naturalcapitalproject.org/RIOS.html
The Missouri Clipper	This tool will generate a ZIP file containing support files needed for SNMP, MMP and RUSLE2. These support files include aerial photo and topographic map images, soil and watershed shapefiles, a digital elevation model raster file, and a RUSLE2 GDB file. Soil data is obtained from the NRCS Web Soil Survey and may be limited by			http://clipper.missouri.edu/index.asp?t=county&state=Minnesota
MapWindow GIS + MMP Tools	MapWindow GIS + MMP Tools is a free GIS that can be used for the following: 1.As a front-end to MMP when creating nutrient management plans. 2.As a front-end to Irris Scheduler when doing irrigation and nitrogen scheduling. 3.For designing research plots (randomized complete block field experiments).			http://www.purdue.edu/agsoftware/mapwindow/
Obejctive Model Custom Weight Tool	A decision support tool designed for USFWS resource managers the ability to make thoughtful and strategic choices about where to spend its limited management resources. This tool makes the processes used to prioritize these management units more transparent, improving the defensibility of management decisions.			http://www.umesc.usgs.gov/management/dss/morris_wmd.html
WARPT: Wetlands-At-Risk Protection Tool	The Wetlands-At-Risk Protection Tool, or WARPT, is a process for local governments and watershed groups that acknowledges the role of wetlands as an important part of their community infrastructure, and is used to develop a plan for protecting at-risk wetlands and their functions. The basic steps of the process include quantifying the			http://www.wetlandprotection.org/

6.4 Usefulness of GIS Data Layers/Tools

Usefulness of GIS Data Layers/Tools for Prioritizing and Targeting Strategies/BMPs

as determined by participants on Day 1 of the Spatial Targeting Workshop on 4/30/14 at the Mankato PCA. See "Tools Inventory" and "Ideas to Prioritize and Target Strategies/BMPs" for more information. This is not an exhaustive list of all data layers/tools that are available or useful. Targeting efforts should select data layers/tools (included here or additionally) based on individual project needs and local priorities.*Note: Some data sets exist in only a very limited extent and may require substantial work before having a usable, spatially referenced data layer.

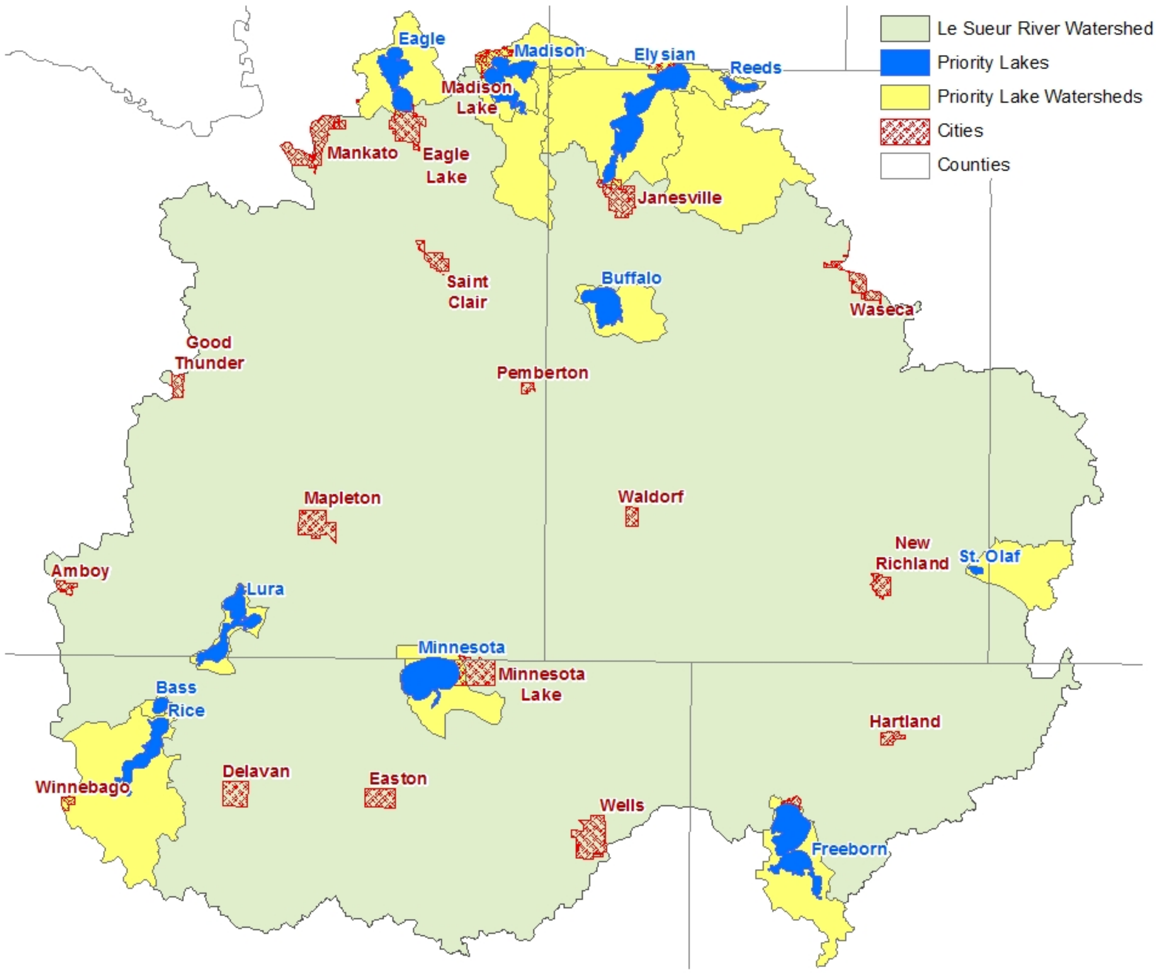
= very/usually useful
= somewhat/sometimes useful
= unsure/need more information
= probably not useful/not applicable



6.5 Water Quality Goal Information

Pollutant/Stressor		Current Condition & Goal Reduction	Equivalent Current & Goal Reduction Load	Baseline Data Source	Goal Determination
Watershed-wide	Excessively High River Flow, Including Peak Flows	25% reduction (from 28 to 21cm annual water yield)	660,000 to 490,000 Ac-ft	2007-2011 average annual flow of Le Sueur River near outlet	sediment rating curve method (see Appendix 6.7)
	Excessively Low River Base Flow	Increase dry season base flow (no numeric goal)	n/a	n/a	n/a
	High TSS Concentrations	65% reduction (from 265 to 90 mg/L)	220,000,000 to 76,000,000 kg*	2007-2011 flow-weighted mean concentration of Le Sueur River near outlet	standard value compared to FWMC
	High TN Concentrations	45% Reduction (from 9 to 5 mg/L)	7,300,000 to 4,000,000 kg*	2007-2011 flow-weighted mean concentration of Le Sueur River near outlet	applied N % reduction from MN State Nutrient Reduction Strategy (MPCA, 2013i)
	High TP Concentrations	60% Reduction (from 0.38 to 0.15 mg/L or 310 to 120 Mg)	310,000 to 120,000 kg*	2007-2011 flow-weighted mean concentration of Le Sueur River near outlet	draft standard value compared to FWMC
	High E. coli Concentrations	50% Reduction (from 251 to 126 mpn/100 mL)	n/a	2008-2010 monthly geo-mean of Le Sueur River near outlet	standard compared to high monthly geomean
	Poor Habitat	Increase habitat (no numeric goal)	n/a	n/a	n/a
Lake Watersheds - High TP concentration		60% Reduction (on average)	see Appendix 6.6	10-year assessment data from Lake Assessment Report (MPCA, 2010)	standard compared to observed concentration, averaged for lakes (see Appendix 6.6)
Cities - Non-point contributions		Reduce at same levels as watershed wide goals	n/a	n/a	n/a

* The water quality goals apply to concentrations, which are inherently affected by the volume of water. These concentration reduction goals are translated to mass using the 5-year average flow. The mass goals were calculated by applying the goal reduction (%) to the observed 5-year annual average mass. In actuality, if flows are reduced and the concentration reductions are met, the total load reduction would be greater than what is presented.



6.6 Individual Lake Phosphorus Reductions

Lake ID	Lake	Observed TP Concentration* (µg/L)	Standard (µg/L)	% Reduction	Modeled TP Load* (kg/yr)
07-0079	Lura	193	90	53%	952
22-0074	Bass	57	90	-	170
22-0075	Rice	218	90	59%	4,544
22-0033	Minnesota	145	90	38%	1,960
24-0044	Freeborn	325	90	72%	2,537
81-0003	St Olaf	37	65	-	67
81-0055	Reeds	29	40	-	65
07-0044	Madison	78	40	49%	1,036
07-0060	Eagle (North)	170	60	65%	790
81-0095	Elysian (Upper)	162	60	63%	2,520
81-0083	Buffalo	222	90	59%	

*Data from Lakes Report (MPCA 2010)

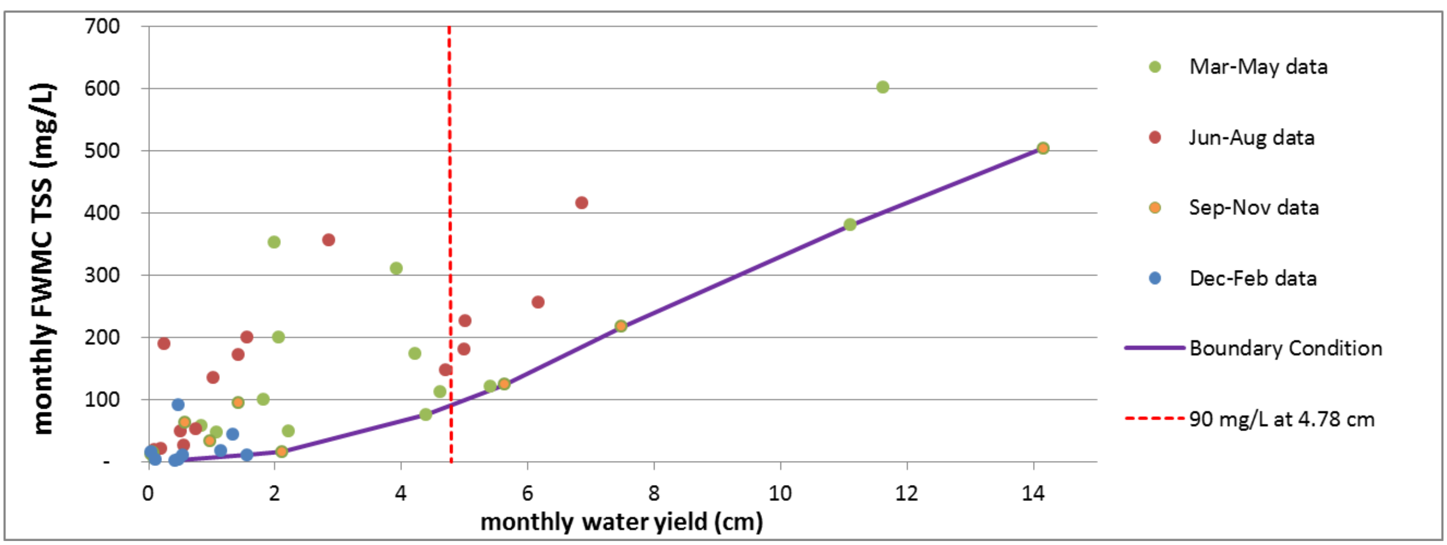
6.7 Flow Target Calculation

Developing flow reduction or hydrology goals is extremely difficult due to the number of variables and unforeseen future changes associated with natural systems. Additionally, there is little research and analytical methods within the literature to suggest appropriate methods to calculate such targets. In this analysis, flow reductions targets were first estimated using several simple methods. Because of the number of unknowns associated with this analysis, a more conservative (lower reduction) method was selected.

The selected method uses the relationship between TSS and monthly flow (sediment rating curve) and a goal TSS value to determine monthly flow reductions that are then translated from individual monthly reductions into an annual reduction. The monthly watershed water yield was plotted versus the FWM monthly concentration data from April 2007-December 2011. Using the lowest concentrations across the range of water yields, a boundary condition was drawn and a power curve was fit to this boundary condition.

This boundary condition can be roughly interpreted as channel-only contributions per yield since a channel-only contribution state is the lowest possible contribution state. In other words, channel contributions are (almost) always present and ravine and upland/field contributions are intermittent and when combined with channel-only contributions, will produce a higher total concentration which can only be greater than the continuous channel-contribution state. Applying this theory, any data point that falls above the boundary condition can be improved by upland and ravine sediment source controls/BMPs. Based on the boundary condition, the maximum monthly flow associated with the goal value (90 mg/L) was drawn (vertical red dotted line at 4.78 cm). Any data point that falls to the right of this line has excessively high flow and is contributing channel-source sediment that cannot be controlled by upland and ravine BMPs only.

To calculate the reduction, any value to the left of the 4.78 cm was ignored since those concentrations can be controlled by upland and ravine BMPs. For any value to the right of that line, the difference between that monthly yield and 4.78 cm was calculated. These differences were summed (31 cm) and that sum was divided by total yield over the examined months (131 cm) to estimate the total annual reduction.



6.8 Lake Restoration and Protection Strategies

Note: this handout is a summary of strategies only. Not all strategies are applicable or appropriate for all lakes or regions. This is not an exhaustive list.

Watershed Strategies – These strategies prevent phosphorus from getting to the lake.

- **Manage nutrients** – carefully planning for and applying phosphorus fertilizers decreases the total amount of phosphorus runoff from cities and fields.
  - Examples: crop nutrient management, city rules on phosphorus fertilizer use, etc.
- **Reduce erosion** – preventing erosion keeps sediment (and attached phosphorus) in place.
  - Examples: construction controls, vegetation (see below)
- **Increase vegetation** – more vegetative cover on the ground uses more water and phosphorus and decreases the total amount of runoff coming from fields and cities.
  - Examples: cover crops, grass buffers, wetlands, prairie gardens/restorations, channel vegetation, etc..
- **Install/restore basins** – capturing runoff and decreasing peak flows in a basin allows the sediment (and attached phosphorus) to settle out.
  - Examples: water and sediment control basins, wetlands, etc..
- **Improve soil health** – soils that are healthy need less fertilizer and hold more water.
  - Examples: reduce/no-till fields, diversified plants in fields and yards

Lake Shore-specific Strategies – These strategies are a subset of watershed strategies that can be directly implemented by lake-shore residents.

- **Eco-friendly landscaping** – poor landscape design and impervious surfaces increase runoff and loading of nutrients into lakes.
  - Examples: aerate, rain barrels, rain gardens, permeable pavers, sprinkler and drainage systems, maintain septic systems, etc..
- **Manage upland buffer zone vegetation** – Upland buffer zone vegetation selection can greatly affect nutrient absorbance, watering needs, erosion potential, need for drainage, etc..
  - Examples: properly landscape, maintain canopy, proper turf grass, reduce watering needs, controlled fertilization and grass clippings.
- **Naturalize transition buffer zone** – a natural transition buffer zone increases absorption of nutrients and decreases erosion potential of the water-shore interface.
  - Examples: balance natural landscaping by minimizing recreational impact area, utilize natural materials for erosion control, minimize beach blankets, plant deep rooted vegetation, preserve and restore emergent aquatic vegetation, do not remove natural wood features.
- **Preserve aquatic buffer zone** – The aquatic buffer zone is difficult to restore, so the best approach is preservation and providing best opportunity for aquatic plants through watershed improvements to increase water quality.
  - Examples: reduce recreational impact area, minimize control of all types of aquatic plants, reduce dock footprint, preserve and/or restore emergent and floating-leaf aquatic plants.

In-Lake Strategies – These strategies use, remove, or seal internal phosphorus (from within the lake). These strategies are only effective if external phosphorus sources are first minimized.

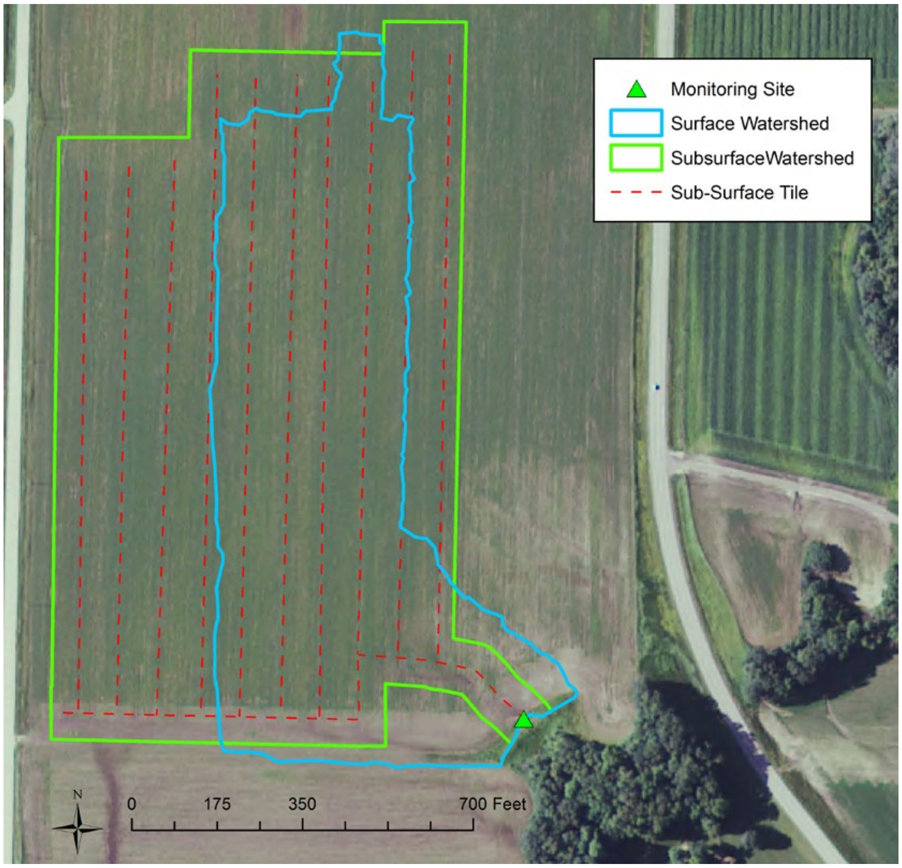
- **Biomanipulation** – changing the fish population. Rough fish are generally bottom feeders and though feeding activity re-suspend sediments and decrease water clarity; thus, removing rough fish through mechanical or biological methods can improve water clarity, increase aquatic vegetation, and improve water quality overall.
  - Examples: commercial netting, balanced fish management, preserve and restore habitat that favors specific fish species, reclamation (kill all fish and start over).
- **Invasive species control of plants and/or animals** – invasive species alter the ecology of a lake and can decrease diversity of habitat when a healthy native diversity exists in a lake.
  - Examples: prevention, early detection, lake vegetation management plan (LVMP)
- **Chemical treatment to seal sediments** – re-suspension of nutrients through wind action can cause internal nutrient loading.
  - Examples: alum treatments.
- **Dredging** – Sedimentation after years of poor watershed practices increases nutrient laden sediments and decreases depth. Dredging can: create channels for access, increase habitat diversity, accommodate recreational use.

6.9 Discovery Farm Information

"Discovery Farms Minnesota is a farmer-led effort to gather field scale water quality information from different types of farming systems, in landscapes all across Minnesota. The mission of the Discovery Farms program is to gather water quality information under real-world conditions. The goal is to provide practical, credible, site-specific information to enable better farm management.

The program is designed to collect accurate measurements of sediment, nitrogen and phosphorus movement over the soil surface and through subsurface drainage tiles. This work leads to a better understanding of the relationship between agricultural management and water quality." –Discovery Farms MN Program

Site BE1 is located just south of Mankato, in the downstream reach of the Cobb River. This discovery farm site captures real-time runoff information from the edge of a tiled corn/soybean field. This dataset is limited at this time (years 2011-2013), does not represent all farms in the region, and does not represent the actual contributions of fields to streams (i.e. the amount of pollutant delivered to a downstream water is less than the total leaving the farm), especially in cases where there is some form of treatment of tile drainage or field runoff. However, in the case of many fields that drain directly into ravines, ditches, or streams (as is the case of the discovery farm in the Le Sueur River Watershed), the pollutant concentrations and loads are nearly direct contributions to the immediate downstream water body. A depiction of the surface and subsurface subwatersheds is included here.



The data are a reflection of a very complex and dynamic system and cannot be extrapolated watershed-wide due to the individual differences in farms (crop types, management, etc.), weather and climatic differences (in particular, precipitation), and topography, soils, and other natural attributes. There are several farms included in the Discovery Farms network, each one producing differing results. For these and other reasons, the data and information relayed is primarily used to conceptually corroborate other source identification work and is not intended to be used for calculations or source proportions in this analysis.

6.10 ET Rate Data & Calculation

The presented ET rates are from the following sources/methodologies:

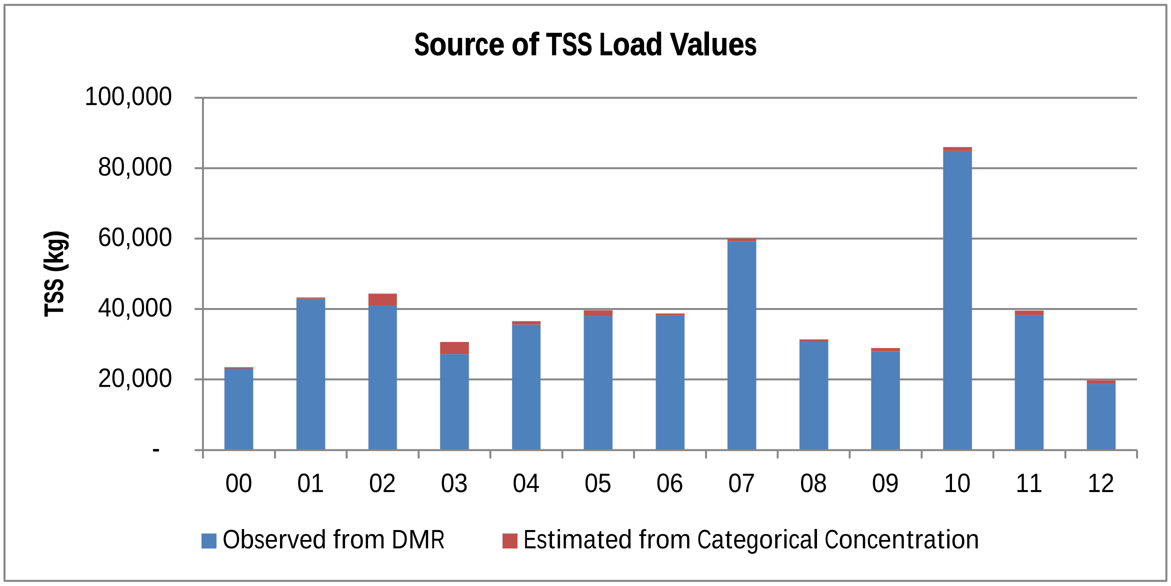
ET rate	Formula/specifics	Reference	Applicable Data
Wetland	$ET_W = 0.9 * ET_{pan}$	Wallace, Nivala, and Parkin (2005)	Waseca station pan ET 1989-2008 average
Lake	$ET_L = 0.7 * ET_{pan}$	Dadaser-Celik and Heinz (2008)	
Crops	Crop ET, Climate II	NRCS (1977)	Table from source

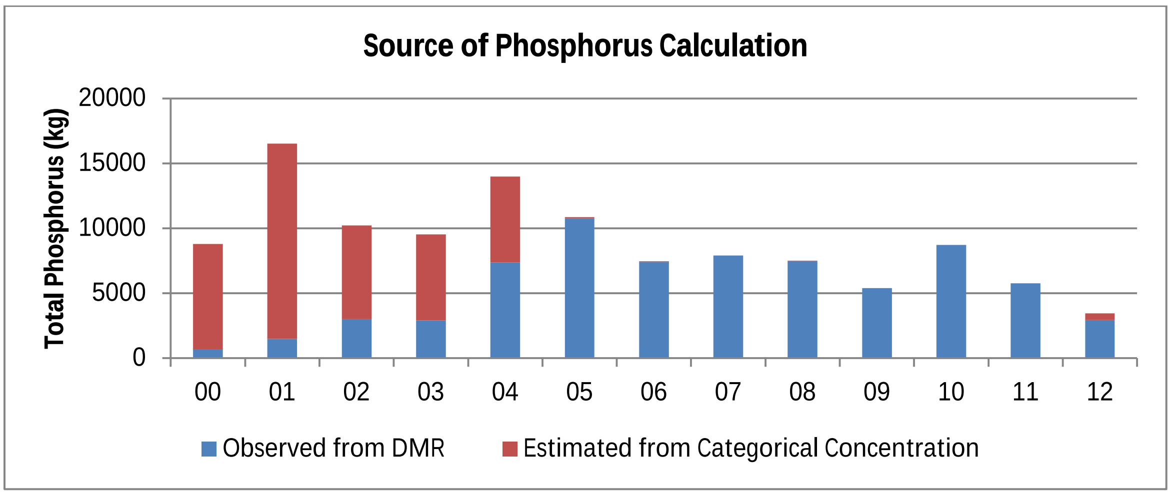
The NRCS crop ET source, despite the source age, was selected because it provided the highest estimates of crop ET. To illustrate this point, the seasonal corn ET rates, as determined from several sources, are presented below:

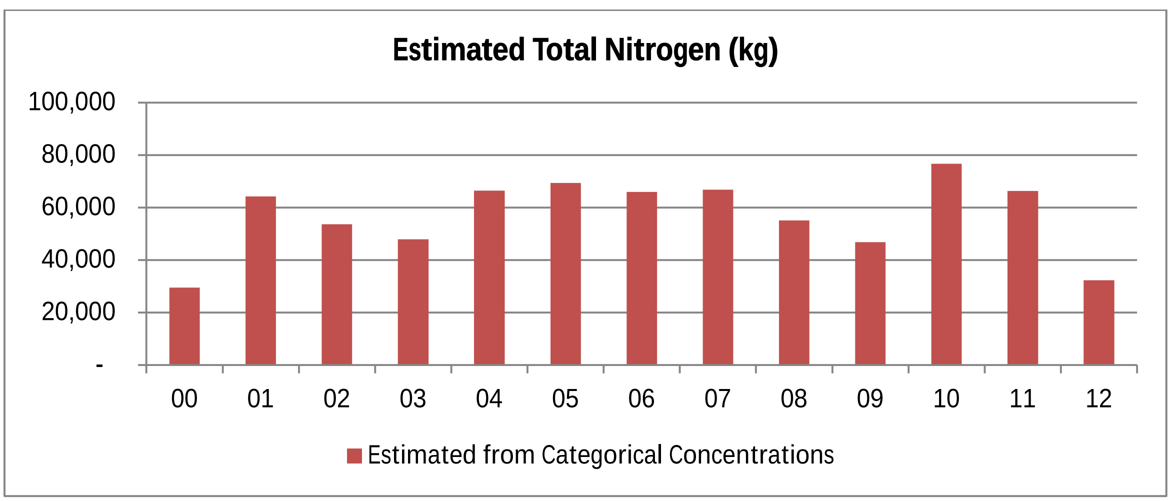
Methodology, data	Source	May-September Corn ET
1. Irrigation table	NRCS (1977)	64 cm
2. SWAT modeling in the Lake Pepin Full Cost Accounting	Dalzell et al. (2012)	54 cm
3. MN Irrigation Scheduling Checkbook, Waseca station temp	NDSU (2012)	42 cm
4. MN Crop Coefficient Curve for Pan ET, Waseca station pan ET	Seeley and Spoden (1982)	39 cm

Using the the highest crop ET rates for comparison was desired for multiple reasons: 1) pan coefficients were developed using older data sets and it is likely that corn, with higher crop densities and larger plant sizes, uses more water today than it did when the coefficients were determined, 2) using lower crop ET rates may appear that the difference between crop and non-crop ET rates was exaggerated, and 3) the use of pan ET rates to estimate ET does have some degree of error, and therefore, the calculated wetland and late ET rates may have some degree of error that could increase the reported difference between wetland/lake ET and crop ET. More information on calculating ET rates is available here: http://deepcreekanswers.com/info/evaporation/ET_water_surf.pdf

6.11 Point Source Data Summary







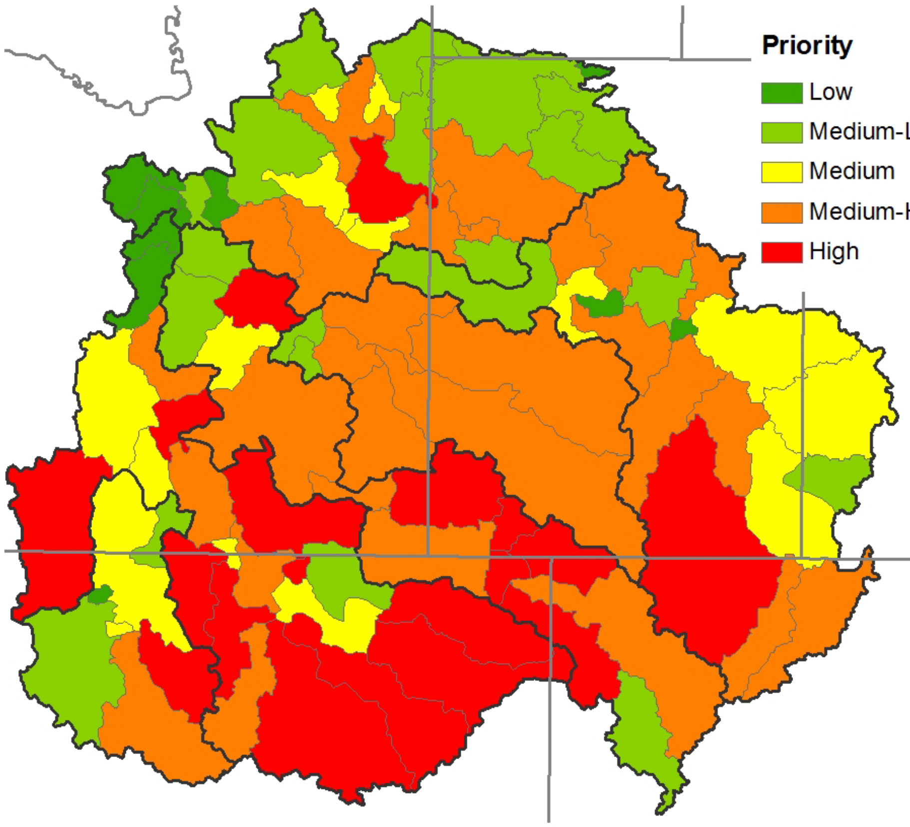
6.12 NPDES Permit Holders in the Le Sueur River Watershed

Facility Type	County	City	Name
Permitted Facility, Individual Permit	Blue Earth	Amboy	Amboy WWTP
Permitted Facility, Individual Permit	Blue Earth	Mapleton	Mapleton WWTP
Permitted Facility, Individual Permit	Blue Earth	St. Clair	Saint Clair WWTP
Permitted Facility, Individual Permit	Faribault	Wells	Wells-Easton-Minnesota Lake WWTP
Permitted Facility, Individual Permit	Waseca	Waseca	Birds Eye Foods Inc - Waseca
Permitted Facility, Individual Permit	Waseca	New Richland	New Richland WWTP
Permitted Facility, Individual Permit	Waseca	Waldorf	Waldorf WWTP
Permitted Facility, Individual Permit	Waseca	Waseca	Waseca WWTP
Permitted Facility, General Permit	Blue Earth	Good Thunder	Good Thunder WWTP
Permitted Facility, General Permit	Blue Earth	Pemberton	Pemberton WWTP
Permitted Facility, General Permit	Blue Earth	Mankato	Blue Earth County Highway Department
Permitted Facility, General Permit	Blue Earth	Good Thunder	Jansen-Hard Rock Quarries Inc
Permitted Facility, General Permit	Blue Earth	Mankato	OMG Midwest Inc/Southern MN Construction Co Inc
Permitted Facility, General Permit	Faribault	Delavan	Delavan WWTP
Permitted Facility, General Permit	Faribault	Wells	Wells Concrete Products Co
Permitted Facility, General Permit	Freeborn	Freeborn	Freeborn WWTP
Permitted Facility, General Permit	Freeborn	Hartland	Hartland WWTP
Permitted Facility, General Permit	Le Sueur	Le Center	Max Johnson Trucking Inc
Permitted Facility, General Permit	Steele	Hope	Witte Brothers Inc
Permitted Facility, General Permit	Waseca	Janesville	Janesville WWTP
Industrial Stormwater Permit	Blue Earth	Good Thunder	Full Circle Organics - Good Thunder Facility - ISW
Industrial Stormwater Permit	Blue Earth	Madison Lake	Pro Fabrication Inc - ISW
Industrial Stormwater Permit	Blue Earth	Mapleton	Protein Sources - Milling Division LLC - ISW
Industrial Stormwater Permit	Steele	Ellendale	Misgen Auto Parts - ISW
Industrial Stormwater Permit	Waseca	Waseca	Brown Printing Co - Waseca Division - ISW
Industrial Stormwater Permit	Waseca	Waseca	Delta-Waseca Inc/Tartan Transportation - ISW
Industrial Stormwater Permit	Waseca	Waseca	DM & E Railroad - Waseca Yard - ISW
Industrial Stormwater Permit	Waseca	Waseca	Waseca County Recycling Center - ISW
Industrial Stormwater Permit	Waseca	Waseca	Waseca Municipal Airport - SW
Feedlot	Blue Earth	Mapleton	Jennie-O Turkey Store - Medo Site Sec 29
Feedlot	Blue Earth	Mapleton	Jennie-O Turkey Store - Medo Site Sec 32
Feedlot	Blue Earth	Good Thunder	Wingen Farms Farm I
Feedlot	Blue Earth	Mapleton	Patrick Duncanson Farm Sec 1
Feedlot	Blue Earth	Mapleton	Lindeland Farms - Sec 35 NE
Feedlot	Blue Earth	Mapleton	Robert Fitzsimmons Farm 1
Feedlot	Blue Earth	Mapleton	Robert Fitzsimmons Farm 2
Feedlot	Blue Earth	Good Thunder	Ivan & Donna Borchardt Farm
Feedlot	Blue Earth	Mapleton	Karl Duncanson Farm - Sec 31
Feedlot	Blue Earth	Mapleton	Bissonette Partnership Farm
Feedlot	Blue Earth	Mapleton	Bissonette Partnership Sterling 16
Feedlot	Blue Earth	Mapleton	McGregor Farms
Feedlot	Blue Earth	Good Thunder	Allen Marble Farm
Feedlot	Blue Earth	Mapleton	Bruce E Maurer Farm
Feedlot	Blue Earth	Mapleton	Marian Moore Farm
Feedlot	Blue Earth	Good Thunder	John Brindley Farm
Feedlot	Blue Earth	Mapleton	Vaubel - Pig Sty Site
Feedlot	Blue Earth	Mapleton	Olson Acres
Feedlot	Blue Earth	Eagle Lake	Darrell Anderegg Farm
Feedlot	Blue Earth	Mapleton	Bruce Ward Farm - Sec 2
Feedlot	Blue Earth	Mapleton	Patrick Duncanson Farm
Feedlot	Blue Earth	Mapleton	Michael L Anderson Farm
Feedlot	Blue Earth	Mapleton	Bruce Ward Farm - Sec 14 Oakhill
Feedlot	Blue Earth	Good Thunder	Flagship Pork Properties
Feedlot	Blue Earth	Mapleton	Hislop Farms LLP
Feedlot	Blue Earth	Mapleton	John Covey Jr Farm Sec 22
Feedlot	Blue Earth	Minnesota Lake	Lindeland Farms - Sec 36
Feedlot	Blue Earth	Amboy	Michael Juergens Farm 1
Feedlot	Blue Earth	Mapleton	Susan Covey Farm Sec 23
Feedlot	Blue Earth	Mapleton	Vaubel - Medo Finishing Site
Feedlot	Blue Earth	Good Thunder	Wingen Farms Farm II
Feedlot	Blue Earth	Good Thunder	David & Dennis Sohre Farm
Feedlot	Blue Earth	Amboy	Caldwell Finishing Inc
Feedlot	Blue Earth	Amboy	Nienow Farm
Feedlot	Blue Earth	Pemberton	Strobel Farms - McPherson 34
Feedlot	Blue Earth	Pemberton	Strobel Farms - McPherson 36
Feedlot	Blue Earth	Mapleton	Vaubel Home Site
Feedlot	Blue Earth	Pemberton	Strobel Farms Sec 23
Feedlot	Blue Earth	Mapleton	Robert Nienow Farm
Feedlot	Faribault	New Richland	North Ridge Farm LLP Site II
Feedlot	Faribault	New Richland	North Ridge Farm LLP Site I

Feedlot	Faribault	Wells	Tom Staloch Farm - Sec 34
Feedlot	Faribault	Winnebago	Bill Schaible Farm
Feedlot	Faribault	Winnebago	South Pork
Feedlot	Faribault	Blue Earth	Becker Farms - Sec 21
Feedlot	Faribault	Easton	Dave Martin Farm
Feedlot	Faribault	Wells	Wetzel Pork
Feedlot	Faribault	New Richland	North Ridge Farm LLP Site III
Feedlot	Freeborn	Ellendale	Darren Hanson Farm
Feedlot	Freeborn	New Richland	Leonard Schultz Farm Unit A
Feedlot	Freeborn	New Richland	Leonard Schultz Farm Unit B
Feedlot	Freeborn	Hartland	Dwayne Stiernagle Farm
Feedlot	Freeborn	Freeborn	Green Power Acres
Feedlot	Waseca	Waseca	Keith Krause Farm - Sec 11 Home
Feedlot	Waseca	Minnesota Lake	KMB
Feedlot	Waseca	Janesville	The Trams Farm Inc Sec 11
Feedlot	Waseca	Minnesota Lake	KMB Inc
Feedlot	Waseca	New Richland	Klimmek Hog Finishing
Feedlot	Waseca	Waseca	SBH Enterprises Pork, LLC
Feedlot	Waseca	Waldorf	Scott & Dale Schweer Farm
Feedlot	Waseca	Waldorf	3-D Pork III
Feedlot	Waseca	Waldorf	Taylor Holland Pork
Feedlot	Waseca	Waseca	Prairie Growers Inc
Feedlot	Waseca	Janesville	The Trams Farm Inc Sec 10
Feedlot	Waseca	Janesville	Calvin Priem Farm
Feedlot	Waseca	Janesville	Burke Farms
Feedlot	Waseca	New Richland	Dale & Todd Joecks Farm
Feedlot	Waseca	Pemberton	Brolsma Hog Farm
Feedlot	Waseca	Janesville	Erdman Farms Inc - Sec 6
Feedlot	Waseca	New Richland	Three Generations Pork Inc
Feedlot	Waseca	New Richland	Brent Possin Farm
Feedlot	Waseca	Minnesota Lake	Choice Connection LLP - Finisher 2
Feedlot	Waseca	Janesville	Erdman Farms Inc Sec 7
Feedlot	Waseca	New Richland	M & S Farms
Feedlot	Waseca	New Richland	Michael & Julie Moen Hogs
Feedlot	Waseca	Janesville	Mike Jewison Farm - Sec 12
Feedlot	Waseca	Minnesota Lake	Terry Traynor Farm
Feedlot	Waseca	New Richland	John Krause Sec 26
Feedlot	Waseca	Waldorf	Peter Sonnek Farm
Feedlot	Waseca	New Richland	Loren Schoenrock Farm
Feedlot	Waseca	Janesville	David Schultz Farm
Feedlot	Waseca	Waseca	Southridge Farms LLP Feedlot
Feedlot	Waseca	New Richland	Buffalo Run Great Plains Family Farms
Feedlot	Waseca	Janesville	Strobel Farms Sec 11
Feedlot	Waseca	Waseca	TDL Farms - Home Site
Feedlot	Waseca	Waseca	FAST Development Inc
Feedlot	Waseca	Waseca	TDL Farms LLP - Guse Site
Feedlot	Waseca	Waseca	Keith Krause Farm - Sec 14
Feedlot	Waseca	New Richland	Hansen Hogs
Feedlot	Waseca	Janesville	Dennis Jewison Farm - Emerald Acres
Feedlot	Waseca	Waseca	Trent & Lisa Armstrong Feedlot
Feedlot	Waseca	Waseca	Below Farms Feedlot

6.13 GIS Hydrologic Alteration Analysis

This is an example of how the layers produced in the GIS hydrologic alteration analysis can be combined to highlight high priority areas for implementing strategies that address altered hydrology. The individual layers are presented in Figure 9 and GIS data layers have been provided to Le Sueur River Watershed staff and are available as requested. Metadata from this analysis is also available upon request.



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6.15 Glossary

Altered hydrology: Changes that have occurred in hydrologic factors including: precipitation, evapotranspiration (ET), and river flow. These changes can be climate- or human-caused.

Assessment Unit Identifier (AUID): The unique water body identifier for each river reach comprised of the USGS eight-digit HUC plus a three-character code unique within each HUC.

Aquatic consumption impairment: Streams are impaired for impacts to aquatic consumption when the tissue of fishes from the water body contains unsafe levels of a human-impacting pollutant. The Minnesota Department of Health provides information on the safe consumption limits for various populations.

Aquatic life impairment: Streams are considered impaired for impacts to aquatic life if the fish Index of Biotic Integrity (IBI), macroinvertebrate IBI, DO, turbidity, or certain chemical standards are not met. The presence and vitality of aquatic life is indicative of the overall water quality of a stream.

Aquatic recreation impairment: Streams are considered impaired for impacts to aquatic recreation if fecal bacteria standards are not met. Lakes are considered impaired for impacts to aquatic recreation if total phosphorus, chlorophyll-a, or Secchi disc depth standards are not met.

Civic Engagement (CE): CE is a subset of public participation (IAP2, 2007) where decision makers involve, collaborate, or empower citizens in the decision making process. The University of Minnesota Extension (2013) provides information on CE and defines CE as "Making resourceful decisions and taking collective action on public issues through processes that involve public discussion, reflection, and collaboration."

Designated (or Beneficial) Use: Water bodies are assigned a designated use based on how the water body is used. Typical beneficial uses include: drinking, swimming, fishing, fish consumption, agricultural uses, and limited uses. Water quality standards for pollutants or other parameters are developed to determine if water bodies are meeting their designated use.

Flow-weighted Mean Concentration (FWMC): The total mass of a pollutant delivered (by water) over a set period of time by the total volume of water over that same period of time. Typical units are: lbs/ac-ft or grams/m^3

Hydrologic Unit Code (HUC): Assigned by the USGS for each watershed. HUCs are organized in a nested hierarchy by size. For example, the Minnesota River Basin is assigned a HUC-4 of 0702 and the Pomme de Terre River Watershed is assigned a HUC-8 of 07020002.

Impairment: Water bodies are listed as impaired if water quality standards are not met for designated uses including: aquatic life, aquatic recreation, and aquatic consumption.

Index of Biotic integrity (IBI): A numerical value between 0 (lowest quality) to 100 (highest quality) that describes water quality using characteristics of aquatic communities.

Protection: This term is used to characterize actions taken in watersheds of waters not known to be impaired to maintain conditions and beneficial uses of the waterbodies.

Restoration: This term is used to characterize actions taken in watersheds of impaired waters to improve conditions, eventually to meet water quality standards and achieve beneficial uses of the waterbodies.

Source (or Pollutant Source): Actions, locations, or entities that deliver/discharge pollutants.

Point Source Pollutant: Pollutants that can be directly attributed to one location; generally, these sources are regulated by permit. Point sources include: waste water treatment plants, industrial dischargers, and storm water discharge from larger cities (MS4 permit (MPCA 2013f)), and storm water runoff from construction activity (construction storm water permit (MPCA 2013g)).

Non-point source pollutants: Pollutants that are from diffuse sources; most of these sources are not regulated. Non-point sources include: agricultural field run-off, agricultural drain tile discharge, storm water from smaller cities and roads, bank, bluff, and ravine failures, atmospheric deposition, failing septic systems, animals, and other sources.

Stream Class 2B: The quality of Class 2B surface waters shall be such as to permit the propagation and maintenance of a healthy community of cool or warm water sport or commercial fish and associated aquatic life and their habitats. These waters shall be suitable for aquatic recreation of all kinds, including bathing, for which the waters may be usable.

Stream Class 2C: The quality of Class 2C surface waters shall be such as to permit the propagation and maintenance of a healthy community of indigenous fish and associated aquatic life and their habitats. These waters shall be suitable for boating and other forms of aquatic recreation for which the waters may be usable.

Stream Class 7 waters: The quality of Class 7 waters of the state shall be such as to protect aesthetic qualities, secondary body contact use, and groundwater for use as a potable water supply.

Stressor (or Biological Stressor): A broad term that includes both pollutant sources and non-pollutant sources or factors (e.g., altered hydrology, dams preventing fish passage) that adversely impact aquatic life.

Total Maximum Daily Load (TMDL) is the maximum amount of a pollutant (or load capacity) a water body can receive without exceeding the water quality standard. In additional to calculating the load capacity, TMDL studies identify pollutant sources by allocating the load capacity between point sources (or wasteload) and non-point sources (or load). Finally, TMDLs calculate the necessary pollutant reductions necessary for a water body to meet its standards.